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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

Enlarged Meeting of the Permanent Commission

(6-8 July, 1939).

Summary of sectional proceedings.

[385. 114 & 656 22]

QUESTION I.

Methods used to speed up passenger trains and the resulting expenditure.

In particular, operating by means of railcars and the financial results obtained by this method.

Preliminary documents.

Report *(Germany, Bulgaria, Denmark, Hungary, Norway, Sweden and Switzerland)*, by Messrs. Rohde, Stroebe and Fesser (See *Bulletin*, June 1939, p. 515).

Report *(Great Britain, India, Dominions and Colonies, North and South America, China and Japan)* by Messrs. T. W. Royle and F. E. Harrison. (See *Bulletin*, May 1939, p. 413.)

Report *(Belgium and Colony, France and Colonies, Greece, Italy, Luxemburg, Netherlands and Colonies, Portugal and Colonies, Rumania, Jugoslavia)*, by Mr. L. Dumas. (See *Bulletin*, June 1939, p. 569.)

Special Report, by Mr. L. Dumas. (See *Bulletin*, July 1939, p. 659.)

SECTIONAL DISCUSSION.

Meeting held on July 6th, 1939 (afternoon).

Mr. Le Besnerais, *General Manager, French National Railways Company, in the Chair.*

The President opened the Meeting at 2 o'clock and welcomed the Delegates.

He then proceeded with the installation of the Bureau of the Section. On behalf of the Permanent Commission he proposed :

as *Vice-Presidents :*

Dr. Ing. eh. J. DORPMÜLLER, Minister of Communications, and General Manager of the German State Railways; and

Mr. VELANI, General Manager of the Italian State Railways;

as *Principal Secretary :*

Mr. CHANTRELL, Engineer, Belgian National Railways Company, Assistant Secretary, International Railway Congress Association ;

as *Secretaries :*

Mr. HENNIG, Engineer, Belgian National Railways Company; and

Mr. BERESFORD, Mechanical Department, London and North Eastern Railway.

The PRESIDENT hoped that the Meeting approved of this choice, and said he was particularly glad Messrs. Dorpmüller and Velani, who are well known to all the delegates, had been nominated vice-presidents.

The PRESIDENT, after making the usual recommendations to the Meeting to facilitate the progress of the discussions, suggested that whereas the agenda in reality consisted of two closely connected questions, only the first be discussed at this meeting, viz : — « Methods used to speed up passenger trains, and the resulting expenditure », and the second part : — « In particular, operating by means of railcars and the financial results obtained by this method » be discussed the following day.

He then defined the lines the discussions would follow. Mr. Dumas, the *Special Reporter*, would summarise his special report on each part of the question. The Reporters and the other delegates would then be called upon to make any statements they might wish to, about this general account. The Special Reporter would then read each of the suggested summaries in turn.

Mr. DUMAS *(Special Reporter)* pointed out that the first part of Question I deals with the speeding up of the passenger trains and the resulting expenditure. The term « passenger trains » covering all methods of traction, steam trains, electric trains, and railcars, he stated that there is a definite connection between the first part of the question and the second part, though the latter would be dealt with more especially at Friday's meeting.

To show how the passenger services have been speeded up, Mr. Dumas recalled the information collected from the various Managements about the number of train-miles worked daily at an average speed of more than 60 miles an hour in 1934, and in 1938.

If only the European railways are considered, this mileage was more than four times greater in 1938 than in 1934, and it increased almost sixfold between 1932 and 1938. Taking all the railways of the world, the daily mileage at more than 60 miles an hour was 93 000 (150 000 km.) in 1938 compared with 25 000 miles (40 000 km.) in 1934, and 6 200 miles (10 000 km.) in 1932. There are therefore five times as many trains at over 60 miles an hour than seven years ago.

Mr. Dumas also recalled the statistics given in his special report about the daily mileage worked at more than 70 miles (112 km.) and more than 75 miles (120 km.) an hour respectively.

Mr. CUTTICA *(Italian State Railways)* pointed out that Italy must now be numbered amongst the countries with a speed above 112 km. (70 miles) an hour, seeing that the speeds on the Florence-Bologna and Naples-Rome lines were increased to 112 and 115 km. (70 and 71.5 miles) an hour respectively on the 1st July 1938.

Mr. DUMAS pointed out that the increase in the maximum speeds is another indication of the way the services have been speeded up. The maximum speeds have been greatly increased in recent years and vary from 160 km. (100 miles) an hour in Germany for the « Schnelltriebwagen », and Italy for the « electro-trains », to 128 km. (79.5 miles) an hour for the Pennsylvania Railroad; in 1932 the maximum speeds normally allowed were of about 120 to 125 km. (75 to 78 miles) an hour on the large railway systems.

At the present time the speed record is held by the Hannover-Hamm « Schnelltriebwagen » with an overall speed of 132.3 km. (82.2 miles) an hour sustained over about 200 km. (125 miles).

Mr. DUMAS reported that on many lines the speeding up of the passenger services coincided with a radical change in the traction conditions, in particular with the electrification of the lines or the introduction of railcars.

In the light of the figures quoted in his special report, he stressed the great achievment of the European railways as regards electrification (increase of 50 % between 1934 and 1938).

As for railcars, at the present time the European Railways have 2 361 railcars in service, compared with a mere 541 in 1934, so that the number has increased more than fourfold in four years.

On the other hand, the services can be considerably speeded up without any radical change of the traction conditions. Many Managements who have not electrified any lines nor developed railcar services, have speeded up their services to a very great extent, particularly by making the engines work harder, reducing the weight of the trains, cancelling the stops at certain stations, or reducing the stopping times.

Before speeding up their trains, the Railways have usually had to put their lines in perfect condition, especially when is was a question of speeds ranging from 140 to 160 km. (87 to 100 miles) an hour.

In many cases the superelevation has had to be increased, particular points improved to remove speed restrictions, the bridges and other structures checked, the level of the running tracks corrected, etc.

Mr. DUMAS made special mention of the Reichsbahn on which a vast programme of permanent way improvements has been undertaken in order to make the lines suitable for very high speeds; 106 million Rm. on the aggregate has been devoted to this purpose during the last ten years.

Certain Companies have estimated the extra cost of permanent way maintenance attribuable to the higher speeds as 10 to 20 %.

On the other hand, in many cases the speeding up of the passenger trains has been done at the expense of their capacity, by reducing the load to be hauled, which has made it necessary to duplicate the services, and this has frequently led to an increase of traffic.

— After this general statement in connection with the first part of the question, on which no comments were made, the President proceeded with the examination of the suggested summaries.

Mr. DUMAS read *Summary I* :

I. — The greatly increased speed of the passenger services during the last five years in most countries is the result of competition from other methods of transport and the general desire for faster travel, both on the main lines and the secondary lines.

For the European Railways taken as a whole, during the last five years, the daily mileage covered at overall speeds of more than 96 km. (60 miles) an hour between two consecutive stops has increased more than fourfold [69 909 km. (43 440 miles) in July, 1938, compared with about 14 557 km. (9 045 miles) in January, 1934].

The PRESIDENT expressed the opinion that in general the speeding up of the services was due *first of all* to a desire for faster travel, and only secondly to competition from other methods of transport. He gave as an example the fact that in France the idea was less to fight competition than to attract new traffic by offering additional facilities. He was under the impression that the German Reichsbahn was following the same impulse in linking up Berlin with other important German cities by such services that it was possible to travel there and back the same day.

Mr. CUTTICA said he quite agreed with the President as far as the Italian State Railways were concerned.

The PRESIDENT suggested therefore that the text proposed be adopted after altering the first paragraph.

The text adopted was as follows :

« I. The greatly increased speed of the passenger services during the last five years in most countries is the result of the general desire for faster travel, and competition from other methods of transport both on the main lines and on the secondary lines.

« For the European Railways taken as a whole, during the last five years, the daily mileage covered at overall speeds of more than 96 km. (60 miles) an hour between two consecutive stops has increased more than fourfold [69 909 km. (43 440 miles) in July, 1938, compared with about 14 557 km. (9 045 miles) in January, 1934]. »

Mr. DUMAS read *Summary II :*

II. — The speeding up of the passenger services on a great number of lines has been the result of a radical change in the traction conditions : electrification, or use of railcars. As a matter of fact, electric motor coaches and railcars, thanks to their light weight and high proportion of driving wheels, are particularly capable of rapid acceleration and retardation, and high speeds.

Mr. MÜLLER *(Swiss Federal Railways)* reported that his Company had built 27-ton vehicles with satisfactory results, and that with trains composed of this stock and two motor units, also of light construction, it is possible to get, besides greater comfort, the same accelerations and speeds as with electric motor coaches; consequently he could not altogether agree with the idea expressed in the second paragraph.

Dr. DORPMÜLLER *(Vice-President,* and *Minister of Communications of the German Reich)* was also of the opinion that the second paragraph should be modified. He quoted the case of a railcar service on one of the German lines, which for a time was replaced by a steam service. Contrary to the opinion held till then, it was found that by running light-weight trains hauled by powerful locomotives it was possible to obtain the same accelerations and speeds as with railcars and electric motor coaches. He therefore suggested that Paragraph 2 be amended in this sense.

The PRESIDENT considered that this question might be divided into two parts : one dealing with the acceleration on starting, and the other with the high speeds. For example it is a very diffe-

rent matter whether the question is one of non-stop services or of services with many stops, such as speeding up suburban services where the need for many stops makes it specially valuable to have stock with great acceleration and deceleration powers; on the other hand, on long non-stop runs steam traction has made such progress recently as was not expected a few years ago.

Mr. CUTTICA expressed the opinion that the speeding up of the passenger services depends on the maximum speed at which the train is authorised to run. In Italy, as no doubt in other countries, the authorised maximum speeds for locomotives are lower than those for railcars.

The PRESIDENT asked if regulations similar to those Mr. Cuttica had just quoted in the case of Italy were in force in other countries ?

Dr. DORPMÜLLER reported that in Germany the maximum authorised speed cannot be run to in practice on many lines, chiefly on account of the curves.

The PRESIDENT agreed that this was also the case in France.

Mr. PORCHEZ *(French National Rys. Co.)* said that the railcars run at a maximum speed one sixth faster, even through curves, as railcars stand up to the lack of superelevation much better than steam locomotives.

Mr. MÜLLER stated that in Switzerland too, in the case of the existing electric locomotives, the maximum speeds are lower than for electric coaches, but in his opinion there was no reason why engines should not be designed which would run through curves just as well as on the straight, at the same speeds as the electric motor coaches, for example light steam locomotives with electric or hydraulic drive.

SIR NIGEL GRESLEY *(London and North Eastern Ry.)* replying to a question from the President, stated that the maximum speed in England with steam locomotives was 125 miles (200 km.) an hour.

Dr. DORPMÜLLER and Mr. STROEBE *(Reporter)* reported that in Germany the maximum speed reached was 215 km. (133.6 miles) an hour with the Kruckenberg type high-speed railcar, and 203 km. (126.1 miles) an hour for steam traction.

The PRESIDENT summed up the opinions expressed and stated that generally speaking the same high speeds were not reached with trains as with railcars, in particular on lines with curves as pointed out by Dr. Dorpmüller.

It was not impossible, however, that engines specially intended for very high speeds would be built.

Mr. LÉVY *(French National Rys. Co.)* did not think it impossible to obtain the same speeds with trains as with railcars, but wondered how the permanent way would be stressed in each case. The electric locomotive exerts less stress on the track than the steam locomotive in which the inertia forces play a very marked part. The electric locomotive has a much greater axle load because the adhesive weight is in fact concentrated, and therefore the track is more heavily stressed than it is in the case of railcars, whether steam, electric or diesel, wherein the adhesive weight is distributed, and consequently local stresses reduced. He thought, therefore, that as regards high speeds, the permanent way department would be more

in favour of railcars which have less effect on the track.

After Messrs. LANER DE ORSOVA *(Royal Hungarian State Rys.)* and ROYLE *(Reporter)* had spoken, the latter suggesting that « in certain countries» be put in the place of « on a great number of lines » in the first paragraph, the PRESIDENT asked Mr. Dumas to sum up the discussions on Summary II and put forward a text to take the various opinions expressed into account.

Mr. DUMAS said that he was prepared to make Mr. Royle's suggested alteration in the first paragraph, but in order not to minimise the meaning, he was in favour of saying : « in many countries » rather than « in certain countries ».

SIR NIGEL GRESLEY, referring to Summary I, suggested saying here that « Speeding up of the passenger services has been made possible by the radical change in the traction conditions... », instead of : « has been the result of a radical change in the traction conditions... ».

Mr. DUMAS read the first paragraph of *Summary II* :

« Speeding up of passenger services in a large number of countries has been made possible by a radical change in traction conditions : electrification or use of railcars ».

— This paragraph was agreed.

Mr. DUMAS then read the second paragraph :

« Electric motor coaches and railcars are particularly suitable for rapid accelerations. Consequently, they are of particular value for services with frequent stops or numerous speed restrictions. »

Mr. DORPMÜLLER suggested adding : « and also for services over heavy gradients ».

The Special Reporter agreed to this, and read the third paragraph :

« Modern light-weight steam and diesel stock is particularly suitable for high-speeds. In practice, the maximum speeds reported are sustained by electric motor coaches or by railcars. »

SIR NIGEL GRESLEY thought it unnecessary to include this 3rd paragraph in Summary II, seeing that it has long been recognised that electric and diesel railcars are particularly suitable for high speeds.

The PRESIDENT suggested that the Reporters might discuss the matter after the Meeting, and agree on a text, something after the following : « Electric motor coaches and railcars, thanks to their light weight and high proportion of driving wheels, are particularly capable of rapid acceleration and retardation. However, with suitable light-weight rolling stock, high effective speeds can be reached with the different forms of traction. »

Mr. DUMAS was of the opinion that it was essential to point out that in the present state of technical knowledge, entirely new types of stock, such as electric motor coaches or railcars sustain the highest maximum speeds run in practice, and which are of about 160 km. (100 miles) an hour in many countries.

He agreed, furthermore, to discussing the final wording with the other Reporters.

Mr. MANGE *(International Union of Railways)* agreed with the President, and said he thought that the Reporters' sum-

maries gave railcars a sort of monopoly of the very high speeds.

Mr. VELANI, *Vice-President (Italian State Railways)*, considered that for the same speeds with the same maintenance of the track, it was necessary to use light-weight rolling stock.

The PRESIDENT said the discussions which had just taken place would give the Reporters who had to draw up the text a very good idea of the opinion of the majority. He would, however, like the Meeting to say whether the opinion prevailed that in practice the same speeds, independently of the stops, could be obtained over the same sections of the lines with trains as with railcars.

Mr. PORCHEZ considered that from the point of view of the track, higher speeds could be obtained with railcars than with steam trains, but if the track conditions were altered to allow of certain speeds with steam trains, still higher speeds could be authorised for lighter vehicles.

Mr. LÉVY pointed out that in addition to what the permanent way and running department thought about it, there was the point of view of the passenger to be considered; perhaps the latter found the heavier trains more comfortable for long journeys.

Mr. DUMAS pointed out that the passengers' point of view was dealt with in Summary VI.

The PRESIDENT suggested adding to the text of Summary II : « with specially designed light-weight rolling stock, high effective speeds can be obtained », in order to point out that it is not impossible to reach these speeds with trains, but that they are as a rule obtained with railcars.

Mr. CUTTICA pointed out that this was a future possibility, and the Summary should only deal with established facts.

The President reminded the Meeting that certain steam trains had reached 200 km. (125 miles) an hour, as Sir Nigel Gresley and Mr. Stroebe had reported.

Mr. DUMAS replied that these were trial trains; in practice, i. e. in regular passenger services the highest overall speeds were obtained with electric motor coaches and with railcars.

Mr. STROEBE suggested replacing « Tatsächlich » (as a matter of fact) by « Im gegenwartigen Zustand » (under present conditions), and said he thought great accelerations could be obtained by using more powerful locomotives or lighter sets, as was the case on the Reichsbahn.

SIR NIGEL GRESLEY expressed the opinion that the summary should not imply that diesel traction was better than steam traction; in hilly districts steam may prove better than the diesel.

— After and exchange of views between SIR NIGEL GRESLEY, and Messrs. DUMAS and MANGE, the President confirmed that the text of Summary II would be revised by the Reporters after the Meeting.

— The *revised text of Summary II* is as follows :

« II. Speeding up of passenger services in a large number of countries has been made possible by a radical change in traction conditions : electrification or use of railcars.

« Very high running speeds can be reached with suitable stock with all

forms of traction. However, from present experience, highest speeds in regular services are reached with electric motor coaches or railcars.

« Moreover, electric motor coaches and railcars are particularly suitable for rapid acceleration. Consequently, they are of special value for fast services having frequent stops or numerous speed restrictions. »

Mr. DUMAS read *Summary III* :

III. — Even when the traction conditions are not radically altered, it is possible to speed up the passenger trains considerably :

(1) by making the locomotives work harder;

(2) by reducing the weight of the trains;

(3) by doing away with stops in certain stations, or shortening the stopping times.

During recent years, many Companies have increased the thermodynamic efficiency of their locomotives and streamlined the locomotives intended for fast services.

In addition, the present state of technical knowledge makes it possible to lighten the construction of metal coaches very considerably.

LORD STAMP *(London Midland and Scottish Ry.)* pointed out that commercially there were no *useless stops*.

He would also like some modification of point (1) as follows : « by increasing the efficiency of the locomotives ».

SIR NIGEL GRESLEY also wanted the expression « by increasing the efficiency of the locomotives » to be used.

Mr. DUMAS pointed out that in some countries, especially in the Netherlands and the United States, it was considered advisable to closely investigate the question of retaining or cancelling certain stops. In the Netherlands, for example, when the operating was reorganised, 148 stations were closed.

Mr. DE AZEVEDO NAZARETH DE SOUZA *(Portuguese Rys. Co.)* considered that in a thinly populated country, it was not possible to do away with any stops, and that from a commercial point of view it was essential to retain a great many stops.

— After Mr. CUTTICA had suggested modifying the summary and Mr. DE BLIECK *(Belgian National Rys. Co.)* had put forward his opinion, the President stated that he agreed to point (1) being modified as Lord Stamp suggested. As for point (3), he did not think the wording of the summary should be altered, but it would be noted in the report on the discussions that naturally it was not intended to imply eliminating stops remaining necessary from the commercial point of view.

Mr. SCHURR *(French National Rys. Co)*, whilst recognising the value of streamlining locomotives, which is being more and more resorted to for new high-speed locomotives, wanted to know if any Companies were systematically streamlining their existing stock of locomotives?

Mr. CUTTICA said that this question was being investigated on the Italian Railways.

Mr. FESSER *(Reporter)* stated that the Reichsbahn considered good results obtained by streamlining, in the case of high speeds. The new high-speed locomotives would be streamlined, and it was also proposed to streamline existing locomotives.

Dr. DORPMÜLLER stressed the fact that streamlining was attractive for speeds of 120 km. (75 miles) an hour and over, but not for lower speeds.

Mr. DE SPIRLET *(Nord Belge Ry.)* asked if Summary III should not refer to the possibility of speeding up the trains by attention to the track, especially by improving the layout.

After an exchange of views between Mr. DUMAS, the PRESIDENT and Mr. DE SPIRLET, it was decided to state at the beginning of Summary V : « In order to speed up their trains... » instead of « Before speeding up their trains... ».

After consideration, it was decided to word Summary III as follows :

« When the traction conditions are not radically altered, it is possible to speed up the passenger trains considerably by:

« (1) making the locomotives work harder or increasing their efficiency;

« (2) reducing the weight of the trains;

« (3) doing away with stops in certain station, or shortening the stopping times.

« During recent years, many Companies have increased the thermodynamic efficiency of their locomotives and streamlined the locomotives intended for fast services.

« In addition, the present state of technical knowledge makes it possible to lighten the construction of metal coaches very considerably ».

Mr. DUMAS read *Summary IV :*

IV. — When the traffic is dense and there is a great difference between the speeds of the different classes of passenger and goods trains, the speeding up of the passenger trains reduces the output capacity of the line and considerably interferes with the other services. When the traffic is light, no difficulty is experienced.

Mr. ROHDE *(Reporter)* stated that the Reichsbahn had found that an adaptation of the goods train timetables made it generally possible to maintain the output capacity of the lines.

Mr. CUTTICA wanted to alter the expression « when the traffic is *light* », in order to prevent any misunderstanding, for example in the case of normal average traffic.

Mr. ROHDE suggested the following addition after « services » : « By the adaptation of the timetables, these difficulties may be reduced ».

— Summary IV was adopted with the suggested modifications, and was worded as follows :

« IV. When the traffic is dense and there is a great difference between the speeds of the different classes of passenger and goods trains, the speeding up of the passenger trains may reduce the capacity of the line and considerably interfere with the other services. By the adaptation of the time-tables, these difficulties may be reduced. When the traffic is light or moderate no difficulty is experienced. »

Mr. DUMAS went on to *Summary V :*

V. — Before speeding up their trains, the Railways have generally had to attend to their lines :

— by increasing the superelevation on curves;

— by improving particular points requiring speed restrictions;

— by examining the bridges;

— by correcting the level of the running road.

After the services have been speeded up, they must pay particular attention to the maintenance of the permanent way, especially as the modern light-weight rolling stock used so far has shown itself very sensitive to imperfections in the track.

Mr. DE SPIRLET suggested deleting the words « attend to their lines » seeing that the track may be in perfect condition for a speed of 100 km. an hour, but have insufficient superelevation for a speed of 120 km. an hour.

Mr. PORCHEZ drew attention to the prime importance of *improving the entry into curves*, as this gives a feeling of comfort, much greater stability, and lower stresses in the track.

Mr. WALLACE *(London Midland and Scottish Ry.)* approved of Mr. Porchez' suggestion, saying that the difficulties experienced are due much more to running onto curves than to the increased superelevation.

He also drew attention to an error in the text of the Special Report in Summary V :

« The L. M. S. R. and L. N. E. R. are also using welded rails 36.50 m. (120 ft.) long with the particular object of increasing the comfort for passengers ». As a matter of fact, the rails were rolled to this length.

Mr. CAMPUS *(Belgian National Rys. Co.)* suggested certain alterations to the text of Summary V, in agreement in particular with the opinions expressed by Messrs. de Spirlet and Porchez. He reminded the Meeting that it is particularly important to improve the curvature of the transitions between the tangents and between circular curves, to make it possible to speed up the trains. The number of particular points requiring speed restrictions should also be reduced as much as possible.

Mr. STANIER *(London Midland and Scottish Ry.)* made a remark about the last paragraph and wanted the words « light-weight » deleted, as up to the present all modern stock was rather sensitive to imperfections in the track.

— The PRESIDENT and Messrs. LÉVY, MÜLLER and STANIER discussed this point, and finally the PRESIDENT suggested that the word « modern » be deleted but the words « light-weight » retained.

Mr. DIJAKIEWICZ *(Ministry of Communications, Poland)* suggested adding : « By improving the signalling ».

Mr. DUMAS agreed. He explained the wording of the final paragraph and suggested deleting the word « modern » and adding at the end : « especially at high speeds ».

— Several delegates discussed this point with the President who finally asked the Meeting to vote on retaining or deleting the words « modern » and « light-weight ». The word « modern » was deleted, and the words « light-weight » retained, adding at the end « especially at high speeds. »

Summary V was therefore adopted with the following wording :

« V. In order to speed up their trains, the Railways have generally had to attend to their lines :

« — by increasing the superelevation and improving the entry to curves;

« — by improving particular points requiring speed restrictions and reducing their number;

« — by examining the structures;

« — by improving the signalling;

« — by correcting the level of the running road.

« After the services have been speeded up, they must pay particular attention to the maintenance of the permanent way, particularly as light-weight rolling stock

so far has shown itself very sensitive to imperfections in the track, especially at high speeds. »

In connection with Summary V, Mr. LÉVY wished to draw the attention of the Meeting to two further points :

(1) as regards light-weight rolling stock, stock on pneumatic tyres is very little affected by imperfections in the track;

(2) it can be concluded from to-day's discussions that heavy vehicles exert greater stresses on the track, and light-weight rolling stock is more sensitive to imperfections in the track.

Mr. DUMAS read *Summary VI :*

VI. — Whilst endeavouring to speed up the services, the Railways should bear in mind the importance of comfort; the passengers want faster, more frequent, and above all more comfortable services.

To assure the success of a new method of traction, by electric motor coach or railcar, it is essential that the rolling stock used be faultless from the point of view of smooth running and the damping out of noise and vibration.

In the second paragraph he suggested replacing « it is essential » by « it is very desirable ». *(Agreed.)*

— The text adopted therefore read :

Whilst endeavouring to speed up the services, the Railways should bear in mind the importance of comfort; the passengers want faster, more frequent, and above all more comfortable services.

To assure the success of a new method of traction, by electric motor coach or railcar, it is very desirable that the rolling stock used be faultless from the point of view of smooth running and the damping out of noise and vibration.

Mr. DUMAS then read *Summary VII :*

VII. — In order to please their passengers, many Managements have been led to increase the number of services as well as to speed them up.

This tendency has encouraged the extension of electrification and railcars in recent years, seeing that with these two methods of traction, the additional train-mile is cheaper than with steam traction.

— This dis not give rise to any remarks, and Summary VII was adopted.

The rest of the discussion was put off till the following day, and the Meeting adjourned at 5 o'clock.

Meeting held on July 7th, 1939 (morning).

Mr. LE BESNERAIS *in the Chair.*

— The Meeting began at 9.20 a. m.

The PRESIDENT told the Meeting that the Reporter had met and agreed on the new wording for Summary II about which there had been a certain divergence of opinions at Thursday's meeting. He read the new text, which gave rise to no comments.

(This new wording is given above, page 871.)

Before asking the Special Reporter to read the remaining Summaries, the PRESIDENT made a point of asking the representatives of the Operating Departments to take part in the discussions of the points on the agenda for this meeting, namely the use of railcars, and the cost,

matters in which the Operating is particularly concerned.

Mr. DUMAS read *Summary VIII :*

VIII. — The use of single or double railcars has often given rise to serious difficulties for the Operating Department as regards meeting peak traffic in a satisfactory way, in particular on secondary lines.

The Managements using multiple-unit railcars, especially triple or quadruple railcars with 2nd and 3rd-class compartments (Holland, Denmark), or 2nd class only (Germany), on the other hand find no difficulty in dealing with peak traffic by coupling their multiple-units together to form sets of 6 vehicles (Germany), 8 vehicles (Denmark) or even 12 vehicles (Holland), so that the capacity corresponds exactly to the traffic.

The PRESIDENT thought that in this connection it would be interesting to obtain certain details from the Railways who couple their railcars together in this way. It is easy to understand that by coupling up several railcars together the peak traffic requirements can be met, but there is also the financial aspect to be considered, and it is not so easy to see how this can be solved. The coupling together of railcars during peak periods not only immobilises the capital invested in the carriages as in the case of a train, but the capital represented by both coaches and engines.

The President consequently asked for further information on this point from the German, Danish and Dutch delegates.

Mr. STROEBE gave details about the economic limits at which the German Reichsbahn now stops using railcars. In the case of four-wheeled railcars : about 100 seats (power unit plus trailer); in the case of eight-wheeled railcars : about 500 seats (2 power units plus 4 trailers with driving compartments). The limits are less clearly defined in the case of the « Schnelltriebwagen », but compared with a steam train working to the same timetable, it is calculated at about 200 seats, which corresponds to two triple sets coupled together.

Replying to the President, Mr. STROEBE reported that when the above limits were exceeded on days of peak traffic, steam trains generally had to be used. In each particular case, a very careful investigation of the costs makes it possible to decide which is the most economical solution.

As regards coupling railcars together, Mr. Stroebe reminded the meeting of the researches undertaken in Germany and the results already obtained with coupling up railcars with different types of drive : mechanical, electric and hydraulic, the whole set being driven by a single man.

The PRESIDENT voiced the opinion that from the technical point of view this was an extremely valuable improvement for the future development of railcars, as it was likely to increase their utility for meeting peak traffics. This particular question of the coupling together of railcars and their trailers seemed to him a very important one, worth special investigation at the next Session.

Mr. DUMAS gave information about the coupling up of railcars in the Netherlands and in Denmark.

In the Netherlands the 40 triplets are used intensively for all the services, to meet both ordinary requirements and peak traffic, being coupled together in trains of 6, 9 or 12 vehicles.

Denmark uses some quadruple sets which are generally coupled together on days of peak traffic, but run as separate units at other times.

The PRESIDENT pointed out that if the Netherlands Rys. have their triplets in constant use, they can have no spare stock for peak periods, so that he wanted to know what took the place of the triplets taken off other lines when a heavy traffic has to be worked on a given line ?

Mr. DUMAS thought that obviously only steam trains could replace triplets taken off some lines.

For peak periods, arrangements are made to take all the stock out of the depots and shops, whereas at normal periods certain vehicles are kept in reserve or undergoing heavy repairs. On peak days, this stock is used to a maximum, with additional shuttle services, and passengers are allowed to stand in the cars in the case of short runs.

The PRESIDENT pointed out that peak traffic sometimes represents 10 to 15 times the usual number of passengers; the technical problem had certainly been solved, but not the operating problem as regards exceptional traffic peaks.

Mr. DUMAS replied that a railway of necessity finds in its stock, in one form or another, the number of seats enabling traffic peaks to be met : the problem consists in determining the proportion of seats which should be available in the form of railcars, bearing in mind that the railcar supplies daily faster and cheaper train-miles than the train and can also share in peak traffic services just as any other vehicle, at a cost per seat available slightly higher than that in a train.

The PRESIDENT concluded that when new stock was being purchased, up to a certain limit it is as well to buy railcars that can be coupled together, so that normally they can be used for the services over a great many sections, and be grouped on certain lines at peak periods, the rolling stock in existence being used at such time on other lines.

Mr. DEMARET *(Belgian National Rys. Co.)* pointed out that on his system railcars are used singly on all the lines, and the operating department was of the opinion that even it were possible to couple the railcars together, peak traffics could not be satisfactorily dealt with in this way. Consequently steam traction is always used instead of railcars, even for regular traffic peaks.

The PRESIDENT summed up the discussions on coupling up railcars by saying that no general solution had yet been found for this problem.

He suggested that the summary be completed by stating that the use of railcars in each particular case has certain economic limits, mainly dictated by the maximum capacity required for traffic peaks, but in many cases the economic efficiency of railcars can be increased by coupling them together or with other stock to form multiple units, when this is possible commercially, to take the place of fairly long trains.

Mr. CUTTICA reported that in Italy, too, heavy peak traffic had to be met by steam traction, as the coupling together of railcars was insufficient.

In reply to the President, Mr. Cuttica stressed the fact that in any case it was necessary to have steam locomotives for the goods services; generally there are railcar services on all the lines radiating from a given centre; if need be the goods locomotives can be used for the passenger services at peak periods, hauling vehicles of the old stock.

The PRESIDENT stated that Mr. Cuttica had raised a very interesting point, namely the possibility of using in the place of railcars, at peak periods, goods locomotives suitable for hauling at express speeds relatively light passenger trains made up of coaches of the old stock.

The President concluded that there is a certain economic limit to the use of railcars, depending on the peak traffic, but that this limit can be extended by coupling the railcars together or with trailers in a very general way, and by using goods locomotives at peak periods to haul certain passenger trains made up of vehicles of the old stock.

An exchange of views between Mr. HÉBERT *(French National Rys. Co.)*, the PRESIDENT, and Mr. ROHDE, showed that generally speaking the number of seats available in certain trains is not limited, but when necessary they are replaced by steam trains.

Mr. DUMAS suggested completing Summary VIII, as indicated by the President, i. e. that :

(1) In practice there is an economic limit for each kind of stock as regards meeting peak traffics; this limit is higher when the stock consists of vehicles that can be coupled together.

(2) On the other hand, the use of goods locomotives capable of working passenger services, facilitates replacing the railcars for periods when the traffic is heaviest.

The PRESIDENT further stressed the point that the speeding up of the passenger train services is largely the result of the use of railcars, but on the other hand the financial balance sheet of the latter must be satisfactory.

He closed the discussion on Summary VIII by suggesting that the Reporters should prepare a text at the end of the Meeting to take the various opinions expressed into account.

— The final text was worded as follows :

« VIII. The use of single or double railcars has often given rise to serious difficulties for the Operating Department, as regards meeting peak traffic in a satisfactory way, particularly on secondary lines.

« Experience has shown that there exists a limit beyond which railcars are no longer suitable economically for periods of peak traffic. This limit is higher when the railcar units can be coupled together.

« In practice, for periods of exceptionally heavy traffic, it is necessary to utilise steam trains at least in some services. The use of steam traction in cases of this kind does not unduly increase costs if goods locomotives suitable for working passenger services, can be used during these times.

« The Managements using multiple-unit railcars, especially triple or quadruple railcars with 2nd or 3rd class compartments (Holland, Denmark) or second class only (Germany for express railcars) on the other hand find no difficulty in dealing with peak traffic, by coupling their multiple units together to form sets of 8 vehicles (Denmark) 9 vehicles (Germany) or even 12 vehicles (Holland), so that the capacity corresponds exactly to the traffic available. »

Mr. DUMAS, before reading Summary IX about the comparative costs of the different methods of traction, commented briefly on the text, reminding the Meeting of the interesting information on this subject given in the three reports.

He then read *Paragraph (1)* of *Summary IX* :

(1) Apart from the capital expenditure on electrification, the cost per mile for an electric train is only about 70 % of that of a steam train of the same capacity.

Mr. MÜLLER pointed out that the text should be made more precise by saying that it was a question of trains working to the same schedule; when electric traction was introduced, the train speeds were generally increased.

Mr. DUMAS suggested that the wording might be modified as follows :

« All other things being equal, leaving aside the initial cost of electrifying the lines, the cost per train-mile for electric traction is only about 70 % of that for steam traction in the case of a train of the same capacity ». He added that 70 % is the average figure.

Mr. BULLEID (*Southern Ry.*, Great Britain) insisted that it was necessary to take into account the capital expenditure on power stations, transformers and distribution lines.

Mr. DUMAS explained that only the traction costs were being compared; naturally the capital cost of electrifying the line had to be taken into account when calculating the total cost.

— After an exchange of opinions between the PRESIDENT and Messrs. DUMAS and ROYLE, is was decided to modify point (1) as follows :

(1) All other things being equal, the cost per mile of an electric train, apart from the initial cost of electrifying the lines, would only be about 70 % of that of a steam train of like capacity.

Mr. DUMAS then read *Clause (2)* :

(2) The cost per mile for a four-wheeled railcar is about 30 % of that for a 3 or 4-coach steam train on secondary lines.

Whilst agreeing that the two were not comparable from the point of view of capacity, Mr. DUMAS pointed out that on many secondary lines where there used to be steam trains, a very great saving had been obtained by replacing the 3 or 4-coach steam trains by a four-wheeled railcar, the capacity of which was sufficient for the traffic. In reply to a question asked by Mr. SCHÜRR, Mr. DUMAS stressed the fact that four-wheeled railcars are used above all on secondary lines, whereas the reports showed that the main-line companies tend more and more to give up using them.

— Clause (2) of Summary IX was adopted as it stood.

Mr. DUMAS went on to *Clause (3)* :

(3) The cost per mile for a bogie railcar of light design without trailer, is about 60 % of that for the steam train on secondary lines.

— Adopted without comment.

Mr. DUMAS read *Clause (4)* :

(4) The cost per mile for a bogie railcar with a trailer is about 75 % of that for the steam train, on secondary lines.

He made it clear that here it was a question of a railcar with a trailer, giving a total of 150 seats compared with a train with 200 seats.

Mr. DE BLIECK pointed out that bogie railcars with a trailer often had a capacity of 240 seats.

Mr. DUMAS stated that here it was a question of 150 seats.

— Clause (4) was adopted without change.

Mr. DUMAS went on to *Clause (5)* of Summary IX :

(5) The cost per mile for a high-speed railcar is 50 to 100 % of that for a steam train of 4 bogie coaches for express services.

He thought the wording should be altered, as the cost per mile for a high-speed railcar varied a very great deal from one Company to another.

LORD ROCKLEY *(Southern Ry.,* Great Britain) also stressed this great variation in cost, i. e. from 50 to 100 %.

At the request of the PRESIDENT, Mr. STROEBE gave certain details about the Reichsbahn. Trials have been carried out, but in general a complete comparison with steam traction had been found impossible. For example, the Berlin-Hamburg service is extremely economical, whilst other services worked by high-speed railcars are less so. He concluded by saying that at the present time it was not possible to give any precise figures.

Mr. HÉBERT pointed out that there was much uncertainty about the amortization period.

Mr. DUMAS suggested the following new wording :

« (5) The cost per mile for a high-speed railcar is extremely variable, according to the type of stock and the operating conditions, but is less than that of a steam train of four bogie coaches for express services. »

— This new text was adopted.

Mr. DUMAS then read the *end of Summary IX :*

Generally speaking, the cost per seat available in a railcar is higher than that of the corresponding seat in a steam train.

In Holland, however, it has been found that the cost per seat available in the triplets, 2nd and 3rd class, is only about 90 % of that for a seat in the trains; three other Managements have reported similar findings in the case of other kinds of equipment.

He added that he particularly wanted to mention the Netherlands in this summary as that country had an experience covering 40 triple sets, which have been in regular service for three or four years, so that very detailed and accurate figures could be given of the total costs.

Moreover, as a result of this experience, the Netherlands had just ordered 20 more five-car sets, which is an obvious proof that the operating results have been satisfactory.

Replying to a question from Mr. HÉBERT, Mr. DUMAS said again that the great length of these sets had not given rise to any garaging difficulties in the Netherlands; the sets were kept in the open, and their air conditioning and heating equipment is so designed that it can stand up to very low temperatures.

Mr. STROEBE, referring to the question of garaging railcars, said that at the beginning the Reichsbahn garaged the large units in closed hangars. As the numbers increased, this practice was given up, and after the railcars have been inspected and cleaned, they are garaged in the open, both summer and winter. As the climate of Germany is more rigorous than that of Holland, certain additional precautions are necessary in winter; for this reason the railcars are fitted with heat-

ing equipment which can work for four hours without attention. If the vehicles are garaged for a longer period, an employee has to check the heating every four hours. These regulations also apply to the small units.

The end of Summary IX was left unaltered, and the Meeting went on to examine Summary X, which Mr. DUMAS read :

X. — The cost of the railcar-mile is relatively high on the one hand because of the maintenance costs, and on the other hand because of the amortisation charges.

Maintenance costs are considerably reduced when the Railway owns a relatively large stock of railcars strictly standardised from the mechanical point of view.

The amortization charges can be reduced when the railcars are so built as to have a long life and give a very high annual mileage.

Experience would seem to show that the amortization of modern railcars ought to be calculated on a period of at least 20 years, and an effective annual mileage of 87 000 (140 000 km.), corresponding to a daily mileage of 250 (400 km.) per railcar of the whole stock.

Mr. LAMALLE *(Belgian National Rys. Co.)* thought it unnecessary to state that the amortization charges are reduced when the railcars are designed to last a long time.

Mr. DUMAS wished to bring out by this statement that in the costs supplied by the various Companies, amortization charges were calculated on a life varying from 6 to 40 years, a very great variation.

The PRESIDENT added that the principle of buying a railcar as cheaply as possible had sometimes been defended; it had finally had to be recognised that it was better to have a railcar with a longer life, though costing rather more.

Mr. HÉBERT pointed out that progress is being made so fast with railcars, that one wonders how many will remain in service for 20 years.

Mr. DUMAS replied that certain European main-line railways state that they now only build railcars intended to last 25 years, precisely on account of the rapid progress made, which naturally does not prevent any improvements being made to their interior fittings.

To a point raised by Mr. YOVITCH *(Jugoslavian State Rys.)* Mr. DUMAS replied that he would agree to making the wording of the first paragraph of Summary X more precise.

Mr. LANER DE ORSOVA *(Royal Hungarian State Rys.)* thought it advisable to discriminate between the life of the engine and that of the coach. On his Railway it had been found that the life of the engine would not exceed 10 years, whereas the coach would certainly last 35.

Mr. STROEBE said that the Reichsbahn also made this distinction for the amortization period.

As regards the coach part, in principle the same period had been adopted as for ordinary rolling stock, namely 30 years, but in order to take into account the greater wear and tear to which railcars are subjected, this period had been reduced to 25 years. A period of 10 years had been adopted for the power plant, though this figure should not be taken as final. The Reichsbahn is trying to obtain a mileage of 125 000 (200 000 km.) between heavy repairs, but up to the

present this has not been achieved with the high-power engines in service.

Mr. CUTTICA pointed out that the Italian State Rys. had not had sufficient experience so far to express a final opinion about the life of the engine. Certain petrol engines have run 250 000 km. (155 000 miles) before heavy repairs. He insisted once more on the need for carrying out heavy repairs so thoroughly that the life of the engine would exceed 10 years.

Mr. HÉBERT reported that in France the mileage between general overhauls of the engine is 120 000 km. (75 000 miles) at the present time; endeavours are being made to increase this figure to 180 000 and 220 000 km. (112 000 and 137 000 miles).

Mr. SCHÜRR thought that repairs should be of such a kind as to enable the engine to last a very long time, as in the case of the steam locomotive.

Mr. HÉBERT remarked that if the various details are replaced frequently, at the end of 10 or 12 years the engine has been completely renewed.

Mr. MÜLLER thought it better to replace the engine by another of an improved type.

Mr. DUMAS, summing up the opinions expressed, said that experience had shown in many countries that the diesel engine, if carefully maintained, could be made as new by repairs after 150 000, 200 000 or 250 000 km. (93 000, 125 000 or 155 000 miles), and consequently had a very long life.

As no Company had more than 10 years' experience of any railcar, none of them can give any final judgment about the life of the engines.

Experience alone will show if it is financially advantageous to make an engine last 10 or 20 years, or better to replace it by a new and more efficient engine at the end of 10.

The PRESIDENT, summing up, said that the railcars themselves had an amortization period similar to that of carriages, but in the case of the engine, the question of the relative importance of the maintenance costs and amortization charges, both factors probably having an effect on each other, had still to be settled. It is interesting to note that with careful maintenance a normal life of at least 10 years could be expected, i. e. at least 1 000 000 km. (620 000 miles).

Mr. SCHÜRR thought that in the present state of experience with this stock, it would seem hazardous to assign more than 20 years' life to the coach part.

Mr. DUMAS then read the amended text of Summary X which took the various remarks made into account.

The first paragraph was modified as follows :

« The cost of the railcar-mile *per seat offered* is high, on the one hand because of the maintenance costs, and on the other hand, because of the amortization charges. »

No changes were made to the 2nd and 3rd paragraphs :

« Maintenance costs are considerably reduced when the Railway owns a relatively large stock of railcars, strictly standardised from the mechanical point of view.

« The amortization charges can be reduced when the railcars are so built as

to have a long life and give a very high annual mileage. »

The last paragraph, in which it was decided to make some reservation as regards the engine, would be worded as follows :

« Experience would seem to show that, apart from the motor portion of the car, the amortization of modern railcars ought to be calculated on a period of at least 20 years, and an effective annual mileage of 87 000 (140 000 km.), corresponding to a daily mileage of 250 (400 km.) per railcar, of the whole stock.

A short exchange of opinions between Messrs. LAMALLE and DUMAS about the last paragraph of the *commentary* on Summary X then took place, about the percentage of railcars in reserve. Mr. Lamalle thought the figure of 5 % given in the Special Report was too low. Mr. DUMAS stressed the fact that with the present stock the reserve is formed in actual fact by the vehicles undergoing repairs or cleaning, as failures rarely occur. Mr. LAMALLE added that this question was merely intended to make the information gathered by Mr. Dumas perfectly clear.

Mr. CUTTICA pointed out that the expression « modern railcars » in the last paragraph of Summary X was not sufficiently definite, seeing that light railcars may be very up to date, but could not possibly last 20 years.

He suggested saying : « modern railcars of particularly robust type ».

Mr. DUMAS admitted the grounds for this remark, and it was decided to say : « ... modern railcars of *robust type* ».

— Summary X was agreed with this amendment.

Mr. DUMAS went on to *Summary XI* :

XI. — In the above investigation into the costs, the figures given only apply to the expenditure on traction, i.e. about 60 % of the total cost of the passenger services.

To complete this investigation, it would be necessary to put into figures the actual or possible effects of the different methods of traction on permanent way maintenance on the one hand, and on operating as a whole, on the other hand.

As regards operating, for example, certain methods of traction should make it possible to obtain such economies as reduction in the number of classes, simplification of the rates, tickets no longer issued in the stations, but by the train staff, etc.

It would be necessary to estimate the additional receipts, with the different methods of traction, resulting from the higher train frequency or the speeding up of the services.

Finally, it would be necessary to estimate the advertising value of some of the speeded up services, which indirectly increase the railway receipts to an appreciable amount.

To sum up, it would be necessary to investigate not only the traction costs for one particular service, but the receipts and expenditure for a group of lines as a whole, taking into account the traffic lost to competitive methods of transport.

Mr. DUMAS added that by this wording he recommends to the Companies to examine each operating balance sheet very closely in a general way, taking the whole of the expenditure into account, i. e. including the expenditure on the permanent way, the operating costs, and also taking the receipts into account.

This summary is indeed more of a programme to be investigated by the International Railway Congress Association.

The PRESIDENT also thought that Summary XI might usefully be included in the agenda for a future Enlarged Meeting of the Permanent Commission. After re-

markable progress in the technical field, the railcar is now used on a large enough scale for the operating side to be investigated. The President suggested that the joint reporters should be chosen from the Operating and Running Departments, so that the two points of view, which usually differ to some extent, would both be brought out as far as possible.

— This suggestion was welcomed by the Meeting, and Summary XI was agreed with a slight modification to the beginning of the 1st paragraph.

Mr. DUMAS read *Summary XII* :

XII. — The Reichsbahn has made a detailed study of the expenditure in terms of the speed, and has been good enough to send us graphs showing the various factors of the total cost in terms of the speed.

Certain expenses increase with the speed (locomotive maintenance and fuel consumption, permanent way maintenance), whilst other items decrease (train staff expenses, amortization charges, etc.); for this reason the total cost of the train-mile reaches a certain minimum for an average speed of 80 km. (50 miles) an hour in the case of express trains.

In this way the Reichsbahn has been able to prove that the speeding up of its passenger services has made it possible to make appreciable savings, quite apart from any effects on the traffic, and that the speeds now practised [73.4 km. (45.6 miles) an hour on the average for the express trains] could be further increased with advantage.

He made it clear that this information was received from the Reichsbahn alone, so that the summary could not be made more general.

He reported in addition that certain isolated particulars given by other Companies do not always agree with the conclusions of the Reichsbahn on the same subject. For example, as regards the rolling stock, the Reichsbahn maintains that when the average speed of the trains is increased, the rolling stock maintenance cost per mile decreases, whereas most of the other Companies hold the opposite view, and stress amongst other things the necessity for still having very smooth running at high speeds, as well as the appreciable cost due to the wear of the brake blocks.

In the same way, as far as the locomotive maintenance costs are concerned, the Reichsbahn considers that this item definitely increases as the speed rises, while other Managements hold the opinion that these costs are more or less constant, on condition that the train load is reduced, as they depend on the power developed by the locomotive, which remains constant.

Mr. ROHDE stressed the fact that the Reichsbahn made a distinction in the graphs in question between coaches and locomotives, and that as far as the locomotives were concerned, the cost increases with the increase in the speed, as is clearly shown by the graphs.

Mr. CUTTICA was of the opinion that the increase in speed corresponded to a reduction in the repair cost.

The PRESIDENT pointed out that the interest of the Reichsbahn's graphs was that they had shown that the total cost of the train-mile will reach a minimum figure under certain conditions. This minimum which, on the Reichsbahn, corresponds to a higher speed than the present average speed, may perhaps correspond to a lower speed than the present average speed on other systems; it depends on the nature of the traffic, the organization of repairs, etc. It is however, very interesting to note that in one

particular case it has been found that the most economical speeds were sometimes higher than the speeds now run; it is certainly desirable to increase the speeds whenever the financial and commercial interests coincide.

The President wanted to know how the graphs in question had been prepared, and if they were based on statistical calculations on the average of all the figures, or on calculations made for a particular case.

Mr. Rohde replied that these graphs were based on a train with average characteristics and running at average speeds, according to the statistics.

The President also wanted to know how the statistics could be collected for speeds of 120 km. (75 miles) an hour.

Mr. Rhode said that the variation, in terms of the speed, of the costs for the trains having average characteristics and running at average speeds had been established theoretically, and by different methods according to the object of the expenditure — staff expenses, interest and depreciation charges, maintenance and improvement costs, or expenditure on materials consumed.

Staff expenses were based on the time. For calculating interest and depreciation charges, the cost of renewal and the life of the various types of vehicles were taken as the basis. In the case of locomotive maintenance and repair costs, a distinction was made between those that vary according to the distance covered, and those that depend on the work done by the locomotive. Whereas the former decrease as the speed rises, the latter increase. The figures admitted were based on information supplied by the shops. The expenditure on locomotive consumptions were determined according to the work actually performed by the engines at the different speeds.

Mr. Franckson *(Belgian National Rys. Co.)* said that amongst the expenses which increased with the speed must be included those on brake blocks, especially when special materials such as ferodo and others were used. He mentioned an interesting observation recorded on the Belgian Railways. Although the problem is not quite the same for all the lines, there is an optimum speed for each given line, and it has been found, for example, that an increase in the time from 41 to 44 minutes on a certain line, will reduce by 50 % the consumption of ferodo, which costs 2 francs per km. There is therefore not only the general problem, but also a special problem for each line, which is essentially a question of the way the stock is driven.

This remark by Mr. Franckson, the interest of which was commented on by the President, completed the discussions on Summary XII, and the text was agreed with a slight modification in the wording of the introduction.

Mr. Dumas then read *Summary XIII :*

XIII. — The Managements who have speeded up and multiplied their passenger services, whilst assuring their comfort at high speeds, have in most cases been able to retain their traffic, and even been able to foster some new traffic, in spite of road or air competition.

Mr. Dumas suggested deleting the word « some » at the end, and saying « ... and even been able to foster new traffic ». He recalled that several countries had insisted on the importance of air competition,

in particular the United States, Switzerland, and Germany.

Certain railways in the United States report, for example, that up to 600 km. (375 miles) they can easily meet air competition, but over 640 km. (400 miles) air competition has the advantage. Between New York and Washington, for example, it seems that the railway is still preferred to the air, because of the comfort offered by the American services.

LORD STAMP *(London Midland and Scottish Ry.)* wanted to know if the fares were the same in this case ? Mr. Dumas had no information at hand on this subject.

— Summary XIII was agreed with the omission proposed by the Special Reporter.

The President closed the Meeting by thanking the Delegates for taking part in the discussions and thereby throwing light on certain aspects of this very important question, affecting as it does the technical and commercial future of the railway. The examination of Question I had made it possible, moreover, to appreciate the important results already obtained by a large number of Companies, and on the other hand — which is a good omen for the future of both the railway and the work of the Congress — showed how many problems there were still to be solved, which would mean new improvements in the future and further interesting discussions. *(Loud applause.)*

— The Meeting ended at 11.55 a. m.

* * *

The full text of the Summaries agreed by the Section and presented to the Plenary Meeting of the 8th July, 1939, is given below.

SUMMARIES.

« I. — The greatly increased speed of the passenger services during the last five years in most countries is the result of the general desire for faster travel, and competition from other methods of transport both on the main lines and on the secondary lines.

« For the European Railways taken as a whole, during the last five years, the daily mileage covered at overall speeds of more than 96 km. (60 miles) an hour between two consecutive stops has increased more than fourfold (69 909 km. — 43 440 miles — in July, 1938, compared with about 14 557 km. — 9 045 miles — in January, 1934).

« II. — Speeding up of passenger services in a large number of countries has been made possible by a radical change in traction conditions : electrification or use of railcars.

« Very high running speeds can be reached with suitable stock with all forms of traction. However, from present experience, highest speeds in regular services are reached with electric motor coaches or railcars.

« Moreover, electric motor coaches and railcars are particularly suitable for rapid acceleration. Consequently, they are of special value for fast services having frequent stops or numerous speed restrictions.

« III. — When the traction conditions are not radically altered, it is possible to speed up the passenger trains considerably by :

« (1) making the locomotives work harder or increasing their efficiency;

« (2) reducing the weight of the trains;

« (3) doing away with stops in certain stations, or shortening the stopping times.

« During recent years, many Companies have increased the thermodynamic efficiency of their locomotives and streamlined the locomotives intended for fast services.

« In addition, the present state of technical knowledge makes it possible to lighten the construction of metal coaches very considerably.

« IV. — When the traffic is dense and there is a great difference between the speeds of the different classes of passenger and goods trains, the speeding up of the passenger trains may reduce the capacity of the line and considerably interfere with the other services. By the adaptation of the time-tables, these difficulties may be reduced. When the traffic is light or moderate, no difficulty is experienced.

« V. — In order to speed up their trains, the Railways have generally had to attend to their lines :

« — by increasing the superelevation and improving the entry to curves;

« — by improving particular points requiring speed restrictions and reducing their number;

« — by examining the structures;

« — by improving the signalling;

« — by correcting the level of the running road.

« After the services have been speeded up, they must pay particular attention to the maintenance of the permanent way, particularly as light-weight rolling stock so far has shown itself very sensitive to imperfections in the track, especially at high speeds.

« VI. — Whilst endeavouring to speed up the services, the Railways should bear in mind the importance of comfort; the passengers want faster, more frequent, and above all more comfortable services.

« To assure the success of a new method of traction, by electric motor coach or railcar, it is very desirable that the rolling stock used be faultless from the point of view of smooth running and the damping out of noise and vibration.

« VII. — In order to please their passengers, many Managements have been led to increase the number of services as well as to speed them up.

« This tendency has encouraged the extension of electrification and railcars in recent years, seeing that with these two methods of traction, the additional train-mile is cheaper than with steam traction.

« VIII. — The use of single or double railcars has often given rise to serious difficulties for the Operating Department as regards meeting peak traffic in a satisfactory way, particularly on secondary lines.

« Experience has shown that there exists a limit beyond which railcars are no longer suitable economically for periods of peak traffic. This limit is higher when the railcar units can be coupled together.

« In practice, for periods of exceptionnally heavy traffic, it is necessary to utilise steam trains at least in some services. The use of steam traction in cases of this kind does not unduly increase costs if goods locomotives suitable for working passenger services, can be used during these times.

« The Managements using multiple-unit railcars, especially triple or quadruple railcars with 2nd or 3rd-class com-

partments (Holland, Denmark) or second class only (Germany for express railcars) on the other hand find no difficulty in dealing with peak traffic, by coupling their multiple units together to form sets of 8 vehicles (Denmark) 9 vehicles (Germany) or even 12 vehicles (Holland), so that the capacity corresponds exactly to the traffic available.

« IX. — (1) All other things being equal, the cost per mile of an electric train, apart from the initial cost of electrifying the lines, would only be about 70 % of that of a steam train of like capacity.

« (2) The cost per mile for a four-wheeled railcar is about 30 % of that for a 3 or 4-coach steam train on secondary lines.

« (3) The cost per mile for a bogie railcar of light design without trailer is about 60 % of that for the steam train on secondary lines.

« (4) The cost per mile for a bogie railcar with a trailer is about 75 % of that for the steam train on secondary lines.

« (5) The cost per mile for a high speed railcar is extremely variable, according to the type of stock and the operating conditions, but is less than that of a steam train of four bogie coaches for express services.

« Generally speaking, the cost per seat available in a railcar is higher than that of the corresponding seat in a steam train.

« In Holland, however, it has been found that the cost per seat available in the triplets, 2nd and 3rd class, is only about 90 % of that for a seat in the trains; three other Managements have reported similar findings in the case of other kinds of equipment.

« The cost of the railcar-mile per seat offered is high, on the one hand because of the maintenance costs, and on the other hand, because of the amortization charges.

« Maintenance costs are considerably reduced when the Railway owns a relatively large stock of railcars, strictly standardised from the mechanical point of view.

« The amortization charges can be reduced when the railcars are so built as to have a long life and give a very high annual mileage.

« Experience would seem to show that apart from the motor portion of the car, the amortization of modern railcars of robust type ought to be calculated on a period of at least 20 years, and an effective annual mileage of 87 000 (140 000 km.), corresponding to a daily mileage of 250 (400 km.) per railcar, of the whole stock.

« XI. — The figures quoted above apply only to expenditure on traction, i. e. about 60 % of the total cost of passenger services.

« To complete this investigation, it would be necessary to put into figures the actual or possible effects of the different methods of traction on permanent way maintenance on the one hand and on operating as a whole, on the other hand.

« As regards operating, for example, certain methods of traction should make it possible to obtain such economies as reduction in the number of classes, simplification of the rates, tickets no longer issued in stations but by train staff, etc.

« It would be necessary to estimate the additional receipts with the different methods of traction, resulting from the higher train frequency or the speeding up of the services.

« Finally, it would be necessary to estimate the advertising value of some of the services speeded up, which directly increase the railway receipts to an appreciable amount.

« To sum up, it would be necessary to investigate not only the traction costs for one particular service, but the receipts and expenditure for a group of lines as a whole, taking into account the traffic lost to competitive methods of transport.

« XII. — From a detailed investigation of the various costs of operation in relation to speed, carried out by the Reichsbahn, it is noted that certain expenses increase with the speed (locomotive maintenance and fuel consumption, permanent way maintenance), whilst other items decrease (train staff expenses, amortization charges, etc.); for this reason the total cost of the train-mile reaches a certain minimum for an average speed of 80 km. (50 miles) an hour in the case of express trains.

« In this way the Reichsbahn has been able to prove that the speeding up of its passenger services has made it possible to make appreciable savings, quite apart from any effects on the traffic, and that the speeds now practised (73.4 km. — 45.6 miles — an hour on the average for the express trains) could be further increased with advantage.

« XIII. — The Managements who have speeded up and multiplied their passenger services, whilst assuring their comfort at high speeds, have in most cases been able to retain their traffic, and even been able to foster new traffic, in spite of road or air competition. »

— These summaries were ratified, subject to a few slight alterations, by the Plenary Meeting held on the 8th July, 1939. (See Proceedings of this Meeting and *Final Summaries* on pp. 900 and 907 of this *Bulletin*.

[656. 2]

QUESTION II.

How should the problems of simplifying the working be considered, in the future, in the interest both of the public and of the railways?

Preliminary documents.

Report *(Main-line Railways of the European Continent, except Belgium)*, by Mr. Goursat. (See *Bulletin*, June 1939, p. 559.)

Report *(Secondary Railways)*, by Dr. Gr. Uff Pietro Lo Balbo. (See *Bulletin*, May 1939, p. 461.)

Report *(English speaking Countries and Belgium)*, by Mr. E. Desorgher. (See *Bulletin*, April 1939, p. 315.)

Special Report, by Mr. E. Desorgher. (See Bulletin, July 1939, p. 669.)

SECTIONAL DISCUSSION.

Meeting held on July 6th, 1939 (afternoon).

Sir H. Nigel Gresley, C. B. E., D. Sc., *Chief Mechanical Engineer, London and North Eastern Railway, in the Chair.*

The President opened the Meeting at 2 o'clock and installed the Bureau. On behalf of the Permanent Commission he proposed :

as *Vice-Presidents :*

Mr. Etter, President, Swiss Federal Railways;

Mr. Goudriaan, President, Netherlands Railways Company;

as *Principal Secretary :*

Mr. Minsart, Engineer, Belgian National Railways Company, and Assistant Secretary, International Railway Congress Association;

as *Secretaries :*

Dr. Sauer, Ministerial Councillor, German Ministry of Communications, and

Mr. Dubus, Engineer, Belgian National Railways Company, and Assistant Secretary, International Railway Congress Association.

— *The Meeting approved of these appointments.*

The President said he was very sorry but he had only heard he would have to preside over the discussions too late to study the reports thoroughly. He had been prepared to follow the discussions on Question I, and therefore asked the Meeting to allow him to resign in favour of Mr. Etter, President of the Swiss Federal Railways. *(Agreed.)*

Mr. Etter *in the Chair.*

The President called upon Mr. Desorgher, the *Special Reporter*, to begin the discussions.

Mr. DESORGHER thought that the only way to sum up the ideas contained in the numerous replies received from the Railways would be to read the rather detailed summaries of the special report. These detailed summaries could, after discussion, be replaced by more concise ones, on which the Meeting would be asked to vote.

Mr. DESORGHER read the Summaries at the end of his special report, commenting briefly on them to outline their classification and define their scope.

— *These summaries were published in the July 1939* BULLETIN, *pages 669 to 672.*

Mr. LO BALBO *(Reporter)* pointed out that Mr. DESORGHER's special report and summaries dealt above all with main-line railways, both their main and less important lines, whereas his own report dealt solely with secondary railway lines, that is to say lines with limited traffic.

Mr. LO BALBO then read the summaries from his report.

— *These summaries were published in the May 1939 Bulletin, pp. 465 and 466.*

Mr. GOURSAT *(Reporter)* called attention to a situation peculiar to the French railways, due to the co-ordination of transport measures introduced rather than to simplification of the operating methods. At the present time in France out of the 42 000 km. (26 100 miles) of lines in operation, there are about 5 000 km. (3 100 miles) on which trains no longer serve all the stations. In accordance with that method of simplification known as « partial passenger co-ordination », the express trains only stop at a certain number of stations, and the small stations are served by road services only.

Mr. LO BALBO said that the Italian Government and Railways were studying co-ordination. Since 1932 a law had been in force allowing the Companies to regroup or amalgamate their lines, in order to simplify the service and reduce expenses. Advantage had already been taken of this law in several instances.

Mr. DESORGHER and Mr. GOUDRIAAN, *Vice-President (Netherlands Railways),* reported that the Netherlands Railways were following a policy similar to that described by Mr. GOURSAT in the case of France. About one third of the stations are no longer served by the trains which only stop at the large centres, to which passengers are brought by the road services.

THE PRESIDENT said that the general discussion was closed, and that the summaries would be discussed point by point.

Mr. DESORGHER said that the Reporters had prepared a new series of summaries which they proposed to put before the Meeting.

THE PRESIDENT opened the discussion on these new summaries, and asked the Special Reporter to read them.

Mr. DESORGHER read *Summary 1 :*

1. — The unfavourable financial position of most Railways, as a result, in particular, of ill-regulated competition between methods of transport, makes it especially necessary to find, in every field, simplified operating methods leading to savings.

Simplification measures may be the result of :

— either lightening of the legal obligations imposed on the Railways,

— or, within the frame of the legal obligations, a rational organization of the work-

ing in order to bring it in line with the actual requirements of the various services.

— Adopted without comment.

Mr. DESORGHER read *Summary 2* :

2. — In order to facilitate the investigations into the savings to be realised, it appears interesting to classify the lines, according to the density and kind of traffic into « main lines » and « secondary lines », to which different operating methods should apply as a matter of principle.

In the case of certain lines or groups of lines, it proves interesting to draw up balance sheets clearly showing the cost prices and the deficit.

Mr. GOURSAT suggested an addition to the first paragraph : « and to obtain more easily from the public authorities some relief from the legal obligations », so that the new wording would be : « In order to facilitate the investigations into the savings to be realised and to obtain more easily from the public authorities some relief from the legal obligations, it appears interesting... »

— This was agreed to, and Summary 2 was adopted with this modification.

Mr. DESORGHER then went on to the next summaries (Nos. 3 to 8), dealing with the « **Main lines** ». — *Summary 3* :

3. — Simplification of the working on main lines should be sought in the field of the fixed installations (buildings and safety plant) and the working conditions of the staff (station staff and train staff).

Mr. LO BALBO did not think it possible to dispense with any buildings, but only to make economies as regards the safety equipment.

Mr. GOURSAT said that sidings that were no longer needed could be taken up. Both the express and slow goods traffic services may also be concentrated in a single shed.

Mr. DESORGHER said that when it became expensive to maintain a useless building in repair, it could be done away with.

Mr. DREYFUS *(French National Rys. Co.)* said that in some towns with several stations, a part could be closed and the buildings let to private firms.

Mr. TUJA *(French National Rys. Co.)* said that on the South-Eastern Area specialised officials are employed to decide which buildings shall be retained and which can be sub-let.

Mr. BALLINARI *(Swiss Federal Rys.)* said that also in Switzerland the question of the utilisation of station premises was being systematically investigated. In certain cases, premises no longer in use had also been let.

Mr. DESSENT *(Belgian National Rys. Co.)* reported that, in Antwerp, warehouses and sheds are hired out for goods from the town. When these goods are sold, they are loaded onto railway wagons. This is consequently advantageous from the traffic point of view. In addition appreciable receipts are obtained from the rents.

— The Section agreed on the following text :

« 3. — Simplification of the working on main lines should be sought in the field of the fixed installations and the working conditions of the staff. »

Mr. DESORGHER read *Summary 4* :

4. — A systematic revision of the build-

ings used for the operation may lead to some of them being dispensed with.

A few Railways have found it an advantage to combine, at the cost of certain inexpensive alterations, the installations used for full wagon load traffic with those for parcels traffic and even for passenger traffic. Such steps should, however, be taken only on condition that the facilities offered to the public are not diminished thereby.

— A few remarks were made about this wording and it was decided to retain only the first part, adding « and tracks », so that the new wording of Summary 4 was :

« 4. — A systematic revision of the buildings and tracks used for the operating may lead to some of them being dispensed with. »

Mr. DESOGRHER went on to *Summary 5:*

5. — The preponderating part played by staff expenses in railway budgets should call, as regards installations, for such solutions as might allow staff reductions to be made, viz. :

— equipping lines carrying heavy traffic with the automatic block;

— bringing all the point and signal operating mechanisms of a station into a central signal box;

— equipping large marshalling yards on modern lines, in order to transfer thereto the work done in neighbouring stations.

He suggested adding to this text :

— reducing the expenditure on level crossing keepers.

Mr. GOURSAT asked if other Railways as well as the French and Italian thought it advantageous to extend the use of the automatic block ?

Mr. WILLAERT *(Belgian National Rys. Co.)* stated that in Belgium, on account of the great number of signal boxes that have to be staffed, there were very few lines where the installation of the automatic block would lead to appreciable economies. Sections were equipped with the automatic block whenever, owing to the frequency of the trains, the manually operated block was too slow.

Mr. GOURSAT reported that when there are no trains stopping during the night in the small stations, no staff is employed.

Mr. DESSENT pointed out that on the Brussels-Antwerp line it is necessary to keep the staff for the goods line which runs beside the electrified line.

Mr. WILLAERT said that the automatic block involves considerable capital expenditure. He was of the opinion that it is easier to make economies by reducing the number of signal boxes, and dispensing with gate keepers or eliminating level crossings.

Mr. TUJA expressed the opinion that when the automatic block is resorted to not only has the staff at the small stations to be dispensed with, but these stations are to be closed down completely at certain times of the day.

In addition, the introduction of the automatic block between manually operated signal boxes is a solution which does not save the whole of the staff, which involves complications at both ends of the manually operated block sections.

Mr. BALLINARI stated that on the St. Gothard line and near Zurich Station, the automatic block had been installed to increase the capacity of the line.

Mr. GOURSAT pointed out that during

certain hours of the day when there are fewer trains, the manually operated boxes can be cut out, but this is a different solution from the introduction of the automatic block which does away with the operation of signals over the whole of the section.

Mr. WILLAERT said that on electrified lines the automatic block is more complicated through having to equip them with inductive connections, and owing to the running of light-weight vehicles.

Perhaps it would be better to make no mention of the automatic block in the summary under discussion.

Mr. GOURSAT asked that it be mentioned, seeing that it was a question of lines carrying heavy traffic. *(Agreed.)*

Mr. DESORGHER read *Summary 6* :

6. — Whenever possible, the putting out of service of certain signal boxes or block signals during periods when they are unnecessary should be considered.

At Mr. DESORGHER's suggestion, and after discussion, it was decided to include this recommendation in Summary 5, the final text of which was :

« 5. — The preponderating part played by staff expenses in railway budgets should call, as regards installations, for such solutions as might allow staff reductions to be made, viz. :

« — equipping lines carrying heavy traffic with the automatic block;

« — bringing all the point and signal operating mechanisms of a station into a central signal box;

« — equipping large marshalling yards on modern lines, in order to transfer thereto the work done in neighbouring stations;

« — reducing the expenditure on level crossing keepers;

« — putting certain signal boxes or block signals out of service during periods when they are unnecessary. »

Mr. DESORGHER then went on to the next Summary, which became No. 6 :

6. — In large stations, particular value is attached to measures tending to proportion as exactly as possible the staff employed to the actual service requirements :

— by using auxiliary labour as stand-by staff;

— by temporarily transferring staff from one department to another;

— by contracting out certain work which does not directly affect the working safety (handling, cleaning).

At Mr. LO BALBO's suggestion, supported by Mr. GOURSAT, the Section decided to leave out the words « In large stations » in view of the fact that this recommendation was a general one.

Mr. BALLINARI pointed out that in Switzerland the carriages are cleaned by cleaners belonging to the regular staff. In the case of spare stock, temporary staff is employed. Wagons can be disinfected in specially equipped stations at fairly close intervals, to which the intermediate stations send their wagons.

Mr. DESSENT reported that in Belgium, wagons are disinfected in disinfection yards.

Mr. DESORGHER reported that on the Belgian Railways, there are also firms who undertake the cleaning of goods wagons.

— After an exchange of views between Messrs. LO BALBO, BALLINARI, GOURSAT and DESORGHER, on the conditions under

which auxiliary labour is employed, it was decided to stipulate that it should not be used for work affecting the working safety, and the following wording was adopted for the final paragraph : « by contracting out certain work which does not directly affect the working safety ».

Mr. DESORGHER then read *Summary 7 :*

7. — As regards stations of small importance, the question should be investigated as to whether they should still be served by rail, or are to be served by road, or again, whether they should preferably be closed for all or part of the traffic.

In such stations, economies can furthermore be obtained :

— by having the duties affecting the working safety and other duties carried out by the same men, or single man;

— by discontinuing all safety measures to be carried out by the station staff; the station can then be managed by a person not on the permanent staff, whose presence will be needed a few hours per day, the remaining duties being carried out by the staff of passing trains.

Mr. GOURSAT made it clear that in small stations on single track lines, a distinction must be made between those stations where trains meet or are overtaken, and those which do not affect the working safety. In the latter, a caretaker can be made responsible for all the other operations.

Mr. BALLINARI reported that in Switzerland only one man is now employed on the train, either a railway or post office employee, who carries out all the necessary duties. The same arrangement is sometimes made with the customs service.

—The suggested wording was adopted without alteration.

Mr. DESORGHER read *Summary 8 :*

8. — It is generally possible to obtain considerable savings on the travelling staff.

The driving staff can be reduced to one man, particularly on electric locomotives or internal-combustion engines, provided such devices as the « dead man » be used, or another employee can intervene in the case of incapacitation of the driver.

The train staff (conductor, guard) can be reduced to one man, or even completely dispensed with in the case of short trains.

Duties affecting the safety are then carried out by the driving staff; such obligations should then be of a particularly simple kind, and it would be interesting to draw up the regulations accordingly.

A discussion in which Messrs. GOURSAT, BALLINARI, DESSENT and DESORGHER took part, made it clear that there is a tendency on several railways to reduce the train staff.

Under certain definite circumstances only one man on the engine need be used. It is also possible to have only one train man. In the case of short trains, no train man need be employed if the engineman is made responsible for certain formalities or safety measures in case of mishaps. It is only necessary to simplify the regulations in force.

— The suggested text was adopted.

Mr. DESORGHER called attention to the fact that Summaries 9, 10 and 11 dealt particularly with the **Secondary Lines of Main-line Railways** and with **Secondary Railways.**

He read *Summary 9 :*

9. — Some Railways have found advantage in having some of their secondary lines worked by light railway Companies, whose staff is better used to simplified working methods than the staff of the main-line railways.

— No comments were made and this text was adopted.

Mr. DESORGHER read *Summary 10 :*

10. — Extreme simplification of the safety plant is possible on a secondary line, in particular the suppression of most of the signals and interlockings.

The regulations governing the operation of the line should also be simplified and adapted to the nature of the traffic and its density : the staff at all stations can be reduced as a consequence or even completely dispensed with, the responsibility as regards train running (meetings, overtaking) resting with the train staff, under the supervision of a single employee for the whole line.

The requirements in connection with the staff escorting the trains on the main lines may be made more flexible in the case of secondary lines.

Mr. GOURSAT was of the opinion that the suggested wording actually covered all the different cases of simplification of the fixed plant and staff reductions reported by the various Managements. The last paragraph, however, might be omitted.

Messrs. GOURSAT, DESORGHER, BALLINARI and LO BALBO discussed whether a single controller should be retained for the whole line, and the Section was in favour of this; the controller should act if it is necessary to alter the crossing points or if the working becomes disordered.

— The wording adopted was the following :

« 10. — Extreme simplification of the safety plant is possible on a secondary line, in particular the suppression of most of the signals and interlockings.

« The regulations governing the operation of the line should also be simplified and adapted to the nature of the traffic and its density : the staff at all stations can be reduced as a consequence or even completely dispensed with, the responsibility as regards train running (meetings, overtaking) resting with the train staff, under the supervision of a single controller for the whole line. »

Mr. DESORGHER read *Summary 11 :*

11. — The rules in the matter of level crossing keeping can be relaxed :

— either by increasing the number of crossings without barriers,

— or by limiting the periods during which crossings are watched.

Against this, it may be necessary to prescribe, for trains arriving at level crossings, special precautions including in particular a speed limit, but one should not go to far in this direction in the case of passenger trains, whose speed might thus be lowered in a too perceptible way.

Mr. LO BALBO was in favour of deleting the last paragraph.

Mr. GOURSAT considered that this paragraph was justified.

It covered the case of crossings where keepers are only employed when trains are passing, and tended to limit, in case of delays, the loss of time caused by the speed restrictions imposed at unguarded crossings.

Mr. LO BALBO pointed out that the steps to be taken depended on the laws in force and might be particular to each country.

— After discussion, the Section decided to substitute the following text for the last paragraph : « Such steps should not, however, result in unfavourable speeds of passenger trains », the rest of the summary being left as it stood.

Mr. LO BALBO asked for a recommenda-

tion that the legislation on secondary railways should be generally simplified, and another insisting on the urgency for co-ordination of transport to be added to the summaries.

— At the PRESIDENT's suggestion, it was decided that an additional summary on these lines would be prepared for the next day's meeting.

— The meeting adjourned at 4.35 p. m.

Meeting held on July 7th, 1939 (morning).

Mr. ETTER *in the Chair.*

— The Meeting was opened at 9.30.

THE PRESIDENT asked the Special Reporter to read the Summaries agreed at the previous meeting.

Mr. Desorgher read these Summaries, and finally a *general remark* suggested by the Reporters as Summary 12 :

General remark.

12. — The application of all the abovementioned simplification measures will relieve the budgets of railway undertakings, but will not be able to put an end to their unfavourable position if the public Authorities do not endeavour to simplify in a general way the legislation on transport, in order to better adapt it to the requirements of the railways and obtain rational co-ordination of all methods of transport.

— As no objections were raised, the PRESIDENT said that the summaries together with this *general remark* were agreed.

THE PRESIDENT then thanked the Reporters and delegates for their valuable assistance.

— The Meeting ended at 10 a. m.

— We give below the complete text of the summaries agreed by the Section.

SUMMARIES.

« 1. — The unfavourable financial position of most Railways, as a result, in particular, of ill-regulated competition between methods of transport, makes it especially necessary to find, in every field, simplified operating methods leading to savings.

« Simplification measures may be the result of :

« — either lightening of the legal obligations imposed on the Railways,

« — or, within the frame of the legal obligations, a rational organisation of the working in order to bring it in line with the actual requirements of the various services.

« 2. — In order to facilitate the investigations into the savings to be realised and to obtain more easily from the public authorities some relief from the legal obligations, it appears interesting to classify the lines, according to the density and kind of traffic, into « main lines » and « secondary lines », to which different operating methods should apply as a matter of principle.

« In the case of certain lines or groups of lines, it proves interesting to draw up balance sheets clearly showing the cost prices and the deficit.

Main lines.

« 3. — Simplification of the working on main lines should be sought in the field of the fixed installations and the working conditions of the staff.

« 4. — A systematic revision of the buildings and tracks used for the operation may lead to some of them being dispensed with.

« 5. — The preponderating part played by staff expenses in railway budgets should call, as regards installations, for such solutions as might allow staff reductions to be made, viz. :

« — equipping lines carrying heavy traffic with the automatic block;

« — bringing all the point and signal operating mechanisms of a station into a central signal box;

« — equipping large marshalling yards on modern lines, in order to transfer thereto the work done in neighbouring stations;

« — reducing the expenditure on level crossing keepers;

« — putting certain signal boxes or block signals out of service during periods when they are unnecessary.

« 6. — Particular value is attached to measures tending to proportion as exactly as possible the staff employed to the actual service requirements :

« — by using auxiliary labour as stand-by staff;

« — by temporarily transferring staff from one department to another;

« — by contracting out certain work which does not directly affect the working safety.

« 7. — As regards stations of small importance, the question should be investigated as to whether they should still be served by rail, or are to be served by road, or again, whether they should preferably be closed for all or part of the traffic.

« In such stations, economies can furthermore be obtained :

« — by having the duties affecting the working safety and other duties carried out by the same men, or single man;

« — by discontinuing all safety measures to be carried out by the station staff; the station can then be managed by a person not on the permanent staff, whose presence will be needed a few hours per day, the remaining duties being carried out by the staff of passing trains.

« 8. — It is generally possible to obtain considerable savings on the travelling staff.

« The driving staff can be reduced to one man, particularly on electric locomotives or internal-combustion engines, provided such devices as the « dead man » be used, or another employee can intervene in the case of incapacitation of the driver.

« The train staff (conductor, guard) can be reduced to one man, or even completely dispensed with in the case of short trains.

« Duties affecting the safety are then carried out by the driving staff; such obligations should then be of a particularly simple kind, and it would be interesting to draw up the regulations accordingly.

Secondary lines of main-line systems and Secondary railways.

« 9. — Some Railways have found advantage in having some of their secondary lines worked by light railway Companies, whose staff is better used to simplified working methods than the staff of the main-line railways.

« 10. — Extreme simplification of the safety plant is possible on a secondary line, in particular the suppression of most of the signals and interlockings.

« The regulations governing the operation of the line should also be simplified and adapted to the nature of the traffic and its density : the staff at all stations can be reduced as a consequence or even completely dispensed with, the responsibility as regards train running (meetings, overtaking) resting with the train staff, under the supervision of a single controller for the whole line.

« 11. — The rules in the matter of level crossing keeping can be relaxed :

« — either by increasing the number of crossings without barriers,

« — or by limiting the periods during which crossings are watched.

« Such steps should not, however, result in unfavourable speeds of passenger trains.

General remark.

« 12. — The application of all the above-mentioned simplification measures will relieve the budgets of railway undertakings, but will not be able to put an end to their unfavourable position if the Public Authorities do not endeavour to simplify in a general way the legislation on transport, in order to better adapt it to the requirements of the railways and obtain rational co-ordination of all methods of transport. »

— The text of these summaries was ratified by the Plenary Meeting held on the 8th July, 1939.

(For the proceedings of this Meeting see pages 900 to 906 of this issue of the *Bulletin.*)

[385. 114, 656.2 & 656.22]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

Enlarged Meeting of the Permanent Commission

6-8 July 1939

Plenary Meeting held on the 8th July, 1939.
PROCEEDINGS.

Mr. RULOT, *President of the Association, in the Chair.*

— The Meeting was opened at 9.30.

THE PRESIDENT stated that the only point on the agenda was the examination of the summaries relating to questions I and II, as adopted by the Sections.

He requested the *General Secretary*, Mr. GHILAIN, to read the proposed summaries in respect of question I :

Methods used to speed up passenger trains and the resulting expenditure. In particular, operating by means of railcars and the financial results obtained by this method.

Mr. GHILAIN read *Summary I* :

I. — The greatly increased speed of the passenger services during the last five years in most countries is the result of the general desire for faster travel, and competition from other methods of transport both on the main lines and on the secondary lines.

For the European Railways taken as a whole, during the last five years, the daily mileage covered at overall speeds of more than 96 km. (60 miles) an hour between two consecutive stops has increased more than fourfold [69 909 km. (43 440 miles) in July, 1938, compared with about 14 557 km. (9 045 miles) in January, 1934].

— No objection being raised, Summary I was adopted.

Mr. GHILAIN read *Summary II* :

II. — Speeding up of passenger services in a large number of countries has been made possible by a radical change in traction conditions : electrification or use of railcars.

Very high running speeds can be reached with suitable stock with all forms of traction. However, from present experience, highest speeds in regular services are reached with electric motor coaches or railcars.

Moreover, electric motor coaches and railcars are particularly suitable for rapid acceleration. Consequently, they are of special value for fast services having frequent stops or numerous speed restrictions.

Mr. GHILAIN stated that, in the second paragraph, the PRESIDENT wished to delete the sentence : — « ... from present experience, highest speeds in regular services are reached with electric motor coaches or railcars » and to combine the 2nd and 3rd paragraphs as follows :

« Very high running speeds can be reached with suitable stock with all forms of traction. However, electric motor coaches and railcars are particularly

suitable for rapid acceleration. Consequently, they are of special value for fast services having frequent stops or numerous speed restrictions ».

— Agreed.

Mr. Le Besnerais (French National Railways Co.) pointed out that the English and German texts did not mention the word « nombreux » (many) at the beginning of the first paragraph, and that the French text should be brought into harmony, as follows : « L'augmentation de la vitesse commerciale des services de voyageurs... ».

— The latter modification was also agreed and Summary II thus amended was adopted.

Mr. Ghilain read *Summary III :*

III. — When the traction conditions are not radically altered, it is possible to speed up the passenger trains considerably by :

(1) making the locomotives work harder or increasing their efficiency;

(2) reducing the weight of the trains;

(3) doing away with stops in certain stations, or shortening the stopping times.

During recent years, many Companies have increased the thermodynamic efficiency of their locomotives and streamlined the locomotives intended for fast services.

In addition, the present state of technical knowledge makes it possible to lighten the construction of metal coaches very considerably.

— Adopted without alteration.

Mr. Ghilain passed on to *Summary IV:*

When the traffic is dense and there is a great difference between the speeds of the different classes of passenger and goods trains, the speeding up of the passenger trains may reduce the capacity of the line and considerably interfere with the other services. By the adaptation of the timetables, these difficulties may be reduced. When the traffic is light or moderate, no difficulty is experienced.

— Mr. Le Besnerais having pointed out that the text in the three languages did not exactly agree, it was decided to word the end of the French text as follows : « Lorsque le trafic est moyen ou faible... » instead of : « Lorsque le trafic n'est pas intense... », the English wording becoming : « When the traffic is moderate or light... ». The summary was ratified with this alteration.

Mr. Ghilain read *Summary V :*

V. — In order to speed up their trains, the Railways have generally had to attend to their lines :

— by increasing the superelevation and improving the entry to curves;

— by improving particular points requiring speed restrictions and reducing their number;

— by examining the structures;

— by improving the signalling;

— by correcting the level of the running road.

After the services have been speeded up, they must pay particular attention to the maintenance of the permanent way, particularly as light-weight rolling stock so far has shown itself very sensitive to imperfections in the track, especially at high speeds.

— Adopted without modification.

Mr. Ghilain read *Summary VI :*

VI. — Whilst endeavouring to speed up the services, the Railways should bear in mind the importance of comfort; the passengers want faster, more frequent, and above all more comfortable services.

To assure the success of a new method of traction, by electric motor coach or railcar, it is very desirable that the rolling stock used be faultless from the point of view of smooth running and the damping out of noise and vibration.

— Adopted without alteration.

Mr. GHILAIN passed on to *Summary VII* :

VII. — In order to please their passengers, many Managements have been led to increase the number of services as well as to speed them up.

This tendency has encouraged the extension of electrification and railcars in recent years, seeing that with these two methods of traction, the additional train-mile is cheaper than with steam traction.

— Adopted as it stood.

Mr. GHILAIN read *Summary VIII* :

VIII. — The use of single or double railcars has often given rise to serious difficulties for the Operating Department, as regards meeting peak traffic in a satisfactory way, particularly on secondary lines.

Experience has shown that there exists a limit beyond which railcars are no longer suitable economically for periods of peak traffic. This limit is higher when the railcar units can be coupled together.

In practice, for periods of exceptionally heavy traffic, it is necessary to utilise steam trains at least in some services. The use of steam traction in cases of this kind does not unduly increase costs if goods locomotives suitable for working passenger services, can be used during these times.

The Managements using multiple-unit railcars, especially triple or quadruple railcars with 2nd or 3rd-class compartments (Holland, Denmark) or second class only (Germany for express railcars) on the other hand find no difficulty in dealing with peak traffic, by coupling their multiple units together to form sets of 8 vehicles (Denmark), 9 vehicles (Germany) or even 12 vehicles (Holland), so that the capacity corresponds exactly to the traffic available.

Mr. LE BESNERAIS, as regards the second paragraph, laid stress on the coupling together not only of railcars, but also of trailers, and he proposed to word the end of this paragraph as follows : « This limit is higher when the railcar units and certain trailers can be coupled together ».

Mr. DUMAS, *Special Reporter*, agreed and proposed that the second paragraph be worded as follows : « Experience has shown that there exists a limit beyond which railcars are no longer suitable economically for periods of peak traffic. The possibility of coupling railcars to trailers, with or without driving posts, permits this limit to be raised noticeably. »

Mr. GHILAIN read *Summary IX* :

IX. — (1) All other things being equal, the cost per mile of an electric train, apart from the initial cost of electrifying the lines, would only be about 70 % of that of a steam train of like capacity.

(2) The cost per mile for a four-wheeled railcar is about 30 % of that for a 3 or 4-coach steam train on secondary lines.

(3) The cost per mile for a bogie railcar of light design without trailer is about 60 % of that for the steam train on secondary lines.

(4) The cost per mile for a bogie railcar with a trailer is about 75 % of that for the steam train on secondary lines.

(5) The cost per mile for a high-speed railcar is extremely variable, according to the type of stock and the operating conditions, but is less than that of a steam train of four bogie coaches for express services.

Generally speaking, the cost per seat available in a railcar is higher than that of the corresponding seat in a steam train.

In Holland, however, it has been found that the cost per seat available in the triplets, 2nd and 3rd class, is only about 90 % of that for a seat in the trains; three other Managements have reported similar findings in the case of other kinds of equipment.

— Adopted without modification.

Mr. GHILAIN read *Summary X* :

The cost of the railcar-mile per seat offered is high, on the one hand because of the maintenance costs, and on the other hand, because of the amortisation charges.

Maintenance costs are considerably reduced when the Railway owns a relatively large stock of railcars, strictly standardised from the mechanical point of view.

The amortisation charges can be reduced when the railcars are so built as to have a long life and give a very high annual mileage.

Experience would seem to show that apart from the motor portion of the car, the amortisation of modern railcars of robust type ought to be calculated on a period of at least 20 years, and an effective annual mileage of 87 000 (140 000 km.), corresponding to a daily mileage of 250 (400 km.) per railcar, of the whole stock.

— After an exchange of views between Messrs. LE BESNERAIS, DUMAS and GHILAIN, it was decided to state at the beginning of the last paragraph : « Experience already acquired would seem... » instead of : « Experience would seem... ».

— Summary X was ratified with this slight alteration.

Mr. GHILAIN passed on to *Summary XI* :

XI. — The figures quoted above apply only to expenditure on traction, i.e. about 60 % of the total cost of passenger services.

To complete this investigation, it would be necessary to put into figures the actual or possible effects of the different methods of traction on permanent way maintenance on the one hand, and on operating as a whole, on the other hand.

As regards operating, for example, certain methods of traction should make it possible to obtain such economies as reduction in the number of classes, simplification of the rates, tickets no longer issued in stations but by train staff, etc.

It would be necessary to estimate the additional receipts with the different methods of traction, resulting from the higher train frequency or the speeding up of the services.

Finally, it would be necessary to estimate the advertising value of some of the services speeded up, which directly increase the railway receipts to an appreciable amount.

To sum up, it would be necessary to investigate not only the traction costs for one particular service, but the receipts and expenditure for a group of lines as a whole, taking into account the traffic lost to competitive methods of transport.

— Adopted without modification.

Mr. GHILAIN read *Summary XII* :

XII. — From a detailed investigation of the various costs of operation in relation to speed, carried out by the Reichsbahn, it is noted that certain expenses increase with the speed (locomotive maintenance and fuel consumption, permanent way maintenance), whilst other items decrease (train staff expenses, amortisation charges, etc.); for this reason the total cost of the train-mile reaches a certain minimum for an average speed of 80 km. (50 miles) an hour in the case of express trains.

In this way the Reichsbahn has been able to prove that the speeding up of its passenger services has made it possible to make appreciable savings, quite apart from any effects on the traffic, and that the speeds now practised (73.4 km. — 45.6 miles — an hour on the average for the express trains) could be further increased with advantage.

— Adopted without alteration.

Mr. GHILAIN read *Summary XIII* :

XIII. — The Managements who have speeded up and multiplied their passenger services, whilst assuring their comfort at high speeds, have in most cases been able

to retain their traffic, and even been able to foster new traffic, in spite of road or air competition.

— Approved.

— The final wording of the summaries relating to Question I is reproduced in the Appendix, pages 907 to 910 of this Bulletin.

* * *

THE PRESIDENT passed on to the summaries adopted by the Section in connection with Question II : « *How should the problems of simplifying the working be considered, in the future, in the interest both of the public and of the railways ?* » and requested Mr. GHILAIN to read them in turn.

Mr. GHILAIN read *Summary I* :

I. — The unfavourable financial position of most Railways, as a result, in particular, of ill-regulated competition between methods of transport, makes it especially necessary to find, in every field, simplified operating methods leading to savings.

Simplification measures may be the result of :

— either lightening of the legal obligations imposed on the Railways,

— or, within the frame of the legal obligations, a rational organisation of the working in order to bring it in line with the actual requirements of the various services.

— No objection being raised, this summary was adopted as it stood.

Mr. GHILAIN read *Summary II* :

II. — In order to facilitate the investigations into the savings to be realised and to obtain more easily from the public authorities some relief from the legal obligations, it appears interesting to classify the lines, according to the density and kind of traffic into « main lines » and « secondary lines », to which different operating methods should apply as a matter of principle.

In the case of certain lines or groups of lines, it proves interesting to draw up balance sheets clearly showing the cost prices and the deficit.

— Adopted without modification.

Mr. GHILAIN passes on to the Chapter : Main lines. — *Summary III* :

III. — Simplification of the working on main lines should be sought in the field of the fixed installations and the working conditions of the staff.

— Adopted.

Summary IV :

IV. — A systematic revision of the buildings and tracks used for the operation may lead to some of them being dispensed with.

— Adopted.

Summary V :

V. — The preponderating part played by staff expenses in railway budgets should call, as regards installations, for such solutions as might allow staff reductions to be made, viz. :

— equipping lines carrying heavy traffic with the automatic block;

— bringing all the point and signal operating mechanisms of a station into a central signal box;

— equipping large marshalling yards on modern lines, in order to transfer thereto the work done in neighbouring stations;

— reducing the expenditure on level crossing keepers;

— putting certain signal boxes or block signals out of service during periods when they are unnecessary.

— Adopted.

Summary VI :

VI. — Particular value is attached to measures tending to proportion as exactly

as possible the staff employed to the actual service requirements :

— by using auxiliary labour as standby staff;

— by temporarily transferring staff from one department to another;

— by contracting out certain work which does not affect directly the working safety.

— Adopted.

Summary VII :

VII. — As regards stations of small importance, the question should be investigated as to whether they should still be served by rail, or are to be served by road, or again, whether they should preferably be closed for all or part of the traffic.

In such stations, economies can furthermore be obtained :

— by having the duties affecting the working safety and other duties carried out by the same men, or single man;

— by discontinuing all safety measures to be carried out by the station staff; the station can then be managed by a person not on the permanent staff, whose presence will be needed a few hours per day, the remaining duties being carried out by the staff of passing trains.

— Adopted.

Summary VIII :

VIII. — It is generally possible to obtain considerable savings on the travelling staff.

The driving staff can be reduced to one man, particularly on electric locomotives or internal-combustion or explosion engines, provided such devices as the « dead-man » be used, or another employee can intervene in the case of incapacitation of the driver.

The train staff (conductor, guard) can be reduced to one man, or even completely dispensed with in the case of short trains.

Duties affecting the safety are then carried out by the driving staff; such obligations should then be of a particuarly simple kind, and it would be interesting to draw up the regulations accordingly.

— Adopted.

Mr. Ghilain then passed on to the Chapter : **Secondary lines of main line systems, and secondary railways.** —

Summary IX :

IX. — Some Railways have found advantage in having some of their secondary lines worked by light railway Companies, whose staff is better used to simplified working methods than the staff of the main-line railways.

— Adopted.

Summary X :

X. — Extreme simplification of the safety plant is possible on a secondary line, in particular the suppression of most of the signals and interlockings.

The regulations governing the operation of the line should also be simplified and adapted to the nature of the traffic and its density : the staff at all stations can be reduced as a consequence or even completely dispensed with, the reponsibility as regards train running (meetings, overtaking) resting with the train staff, under the supervision of a single controller for the whole line.

— Adopted.

Summary XI :

XI. — The rules in the matter of level crossing keeping can be relaxed :

— either by increasing the number of crossings without barriers,

— or by limiting the periods during which crossings are watched.

Such steps should not, however, result in unfavourable speeds of passenger trains.

— Adopted.

Mr. GHILAIN finally read *Summary XII*, entitled : General remark.

XII. — The application of all the above-mentioned simplification measures will relieve the budgets of railway undertakings, but will not be able to put an end to their unfavourable position if the Public Authorities do not endeavour to simplify in a general way the legislation on transport, in order to better adapt it to the requirements of the railways and obtain rational co-ordination of all methods of transport.

— Adopted.

— The final text of the Summaries relating to Question II is reproduced in the Appendix, pages 910 to 912 of this Bulletin.

* * *

After the Summaries had been ratified the PRESIDENT expressed his best thanks to all those in attendance, and he heartily congratulated the Reporters on their very valuable contribution to the success of the Meeting.

He then dwelt on the fact that the ratification of the proposed summaries constituted a further step towards the conversion of the railway operating methods, which conversion — as he already stated at the 1935 Meeting — tends to lower the cost of rail transport in order to fight competition and adapt the railways to present-day requirements. It is actually part of the transport co-ordination which in some way is in progress, without it being properly realised, for the aim of such co-ordination is not only to regulate competition, but also to make it actually possible to adapt the railway undertakings to the new circumstances.

The President agreed in particular with the general remark which appears at the end of the summaries relating to Question II, this remark meaning that the railways will still be confronted with very difficult problems as long as the Public Authorities will not have taken general steps which will enable the railways to be alive to their technical progress and their future as well as to be constantly on the look-out for restrictions in order to meet competition.

The President concluded by wishing the Delegates a pleasant time while they stayed on in Belgium and a happy return in their respective countries. *(Loud applause.)*

— The Meeting was closed at 10.30.

[385. 06. 111]

SUMMARIES

adopted by the Plenary Meeting of the Permanent Commission (8th July, 1939)

QUESTION I.

Methods used to speed up passenger trains and the resulting expenditure. In particular, operating by means of railcars and the financial results obtained by this method.

SUMMARIES.

« I. — The greatly increased speed of « the passenger services during the last « five years in most countries is the re- « sult of the general desire for faster « travel, and competition from other me- « thods of transport both on the main « lines and on the secondary lines.

« For the European Railways taken as « a whole, during the last five years, the « daily mileage covered at overall speeds « of more than 96 km. (60 miles) an « hour between two consecutive stops « has increased more than fourfold « [69 909 km. (43 440 miles) in July, « 1938, compared with about 14 557 km. « (9 045 miles) in January, 1934].

« II. — Speeding up of passenger ser- « vices in a large number of countries « has been made possible by a radical « change in traction conditions : electri- « fication or use of railcars.

« Very high running speeds can be « reached with suitable stock with all « forms of traction; however, electric « motor coaches and railcars are parti- « cularly suitable for rapid acceleration. « Consequently, they are of special value « for fast services having frequent stops « or numerous speed restrictions.

« III. — When the traction conditions « are not radically altered, it is possible « to speed up the passenger trains con- « siderably by :

« (1) making the locomotives work « harder or increasing their efficiency;

« (2) reducing the weight of the « trains;

« (3) doing away with stops in certain « stations, or shortening the stopping ti- « mes.

« During recent years, many Compa- « nies have increased the thermodynamic « efficiency of their locomotives and « streamlined the locomotives intended « for fast services.

« In addition, the present state of tech- « nical knowledge makes it possible to « lighten the construction of metal « coaches very considerably.

« IV. — When the traffic is dense and « there is a great difference between the « speeds of the different classes of pas- « senger and goods trains, the speeding « up of the passenger trains may reduce « the capacity of the line and consider- « ably interfere with the other services. « By the adaptation of the time-tables,

« these difficulties may be reduced. « When the traffic is moderate or light, « no difficult is experienced.

« V. — In order to speed up their « trains, the Railways have generally had « to attend to their lines :

« — by increasing the superelevation « and improving the entry to curves;

« — by improving particular points re- « quiring speed restrictions, and reduc- « ing their number;

« — by examining the structures;

« — by improving the signalling;

« — by correcting the level of the « running road.

« After the services have been speeded « up, they must pay particular attention « to the maintenance of the permanent « way, particularly as light-weight rol- « ling stock so far has shown itself very « sensitive to imperfections in the track, « especially at high speeds.

« VI. — Whilst endeavouring to speed « up the services, the Railways should « bear in mind the importance of com- « fort; the passengers want faster, more « frequent, and above all more comfort- « able services.

» To assure the success of a new me- « thod of traction, by electric motor « coach or railcar, it is very desirable « that the rolling stock used be faultless « from the point of view of smooth run- « ning and the damping out of noise and « vibration.

« VII. — In order to please their pas- « sengers, many Managements have been « led to increase the number of services « as well as to speed them up.

« This tendency has encouraged the ex- « tension of electrification and railcars « in recent years, seeing that with these « two methods of traction, the additional « train-mile is cheaper than with steam « traction.

« VIII. — The use of single or double « railcars has often given rise to serious « difficulties for the Operating Depart- « ment, as regards meeting peak traffic « in a satisfactory way, particularly on « secondary lines.

« Experience has shown that there « exists a limit beyond which railcars « are no longer suitable economically for « periods of peak traffic. The possibili- « ty of coupling railcars to trailers, with « or without driving posts, permits this « limit to be raised noticeably.

« In practice, for periods of exception- « ally heavy traffic, it is necessary to uti- « lise steam trains at least in some servi- « ces. The use of steam traction in cases « of this kind does not unduly increase « costs if goods locomotives suitable for « working passenger services can be « used during these times.

« The managements using multiple- « unit railcars, especially triple or qua- « druple railcars with 2nd or 3rd-class « compartments (Holland, Denmark) or « second class only (Germany for ex- « press railcars) on the other hand find « no difficulty in dealing with peak traf- « fic, by coupling their multiple units « together to form sets of 8 vehicles « (Denmark), 9 vehicles (Germany) or « even 12 vehicles (Holland), so that the « capacity corresponds exactly to the « traffic available.

« IX. — (1) All other things being « equal, the cost per mile of an electric « train, apart from the initial cost of « electrifying the lines, would only be « about 70 % of that of a steam train of « like capacity.

« (2) The cost per mile for a four- « wheeled railcar is about 30 % of that

« for a 3 or 4-coach steam train on se-« condary lines.

« (3) The cost per mile for a bogie « railcar of light design without trailer « is about 60 % of that for the steam « train on secondary lines.

« (4) The cost per mile for a bogie « railcar with a trailer is about 75 % of « that for the steam train on secondary « lines.

« (5) The cost per mile for a high-« speed railcar is extremely variable, ac-« cording to the type of stock and the « operating conditions, but is less than « that for a steam train of four bogie « coaches for express services.

« Generally speaking, the cost per seat « available in a railcar is higher than « that of the corresponding seat in a « steam train.

« In Holland, however, it has been « found that the cost per seat available « in the triplets, 2nd and 3rd class, is « only about 90 % of that for a seat in « the trains; three other Managements « have reported similar findings in the « case of other kinds of equipment.

« X. — The cost of the railcar-mile per « seat offered is high, on the one hand « because of the maintenance costs, and « on the other hand, because of the « amortisation charges.

« Maintenance costs are considerably « reduced when the Railway owns a re-« latively large stock of railcars, strictly « standardised from the mechanical « point of view.

« The amortisation charges can be re-« duced when the railcars are so built as « to have a long life and give a very high « annual mileage.

« Experience already acquired would « seem to show that apart from the mo-« tor portion of the car, the amortisation « of modern railcars of robust type « ought to be calculated on a period of at « least 20 years, and an effective annual « mileage of 87 000 (140 000 km.), cor-« responding to a daily mileage of 250 « (400 km.) per railcar, of the whole « stock.

« XI. — The figures quoted above ap-« ply to expenditure on traction, i.e. « about 60 % of the total cost of passen-« ger services.

« To complete this investigation, it « would be necessary to put into figures « the actual or possible effects of the « different methods of traction on per-« manent way maintenance on the one « hand and on operating as a whole, on « the other hand.

« As regards operating, for example, « certain methods of traction should « make it possible to obtain such econo-« mies as reduction in the number of « classes, simplification of the rates, « tickets no longer issued in stations but « by train staff, etc.

« It would be necessary to estimate the « additional receipts with the different « methods of traction, resulting from the « higher train frequency or the speeding « up of the services.

« Finally, it would be necessary to esti-« mate the advertising value of some of « the services speeded up, which, direct-« ly increase the railway receipts to an « appreciable amount.

« To sum up, it would be necessary to « investigate not only the traction costs « for one particular service, but the re-« ceipts and expenditure for a group of « lines as a whole, taking into account « the traffic lost to competitive methods « of transport.

« XII. — From a detailed investigation

« of the various costs of operation in re- « lation to speed, carried out by the « Reichsbahn, it is noted that certain ex- « penses increase with the speed (loco- « motive maintenance and fuel consump- « tion, permanent way maintenance), « whilst other items decrease (train staff « expenses, amortisation charges, etc.); « for this reason the total cost of the « train-mile reaches a certain minimum « for an average speed of 80 km. (50 mi- « les) an hour in the case of express « trains.

« In this way the Reichsbahn has been « able to prove that the speeding up of « its passenger services has made it pos- « sible to make appreciable savings, qui- « te apart from any effects on the traf- « fic, and that the speeds now practised « [73.4 km. (45.6 miles) an hour on the « average for the express trains] could « be further increased with advantage.

« XIII. — The Managements who have « speeded up and multiplied their pas- « senger services, whilst assuring their « comfort at high speeds, have in most « cases been able to retain their traffic, « and even been able to foster new traf- « fic, in spite of road or air competi- « tion ».

QUESTION II.

How should the problems of simplifying the working be considered, in the future, in the interest both of the public and of the railways ?

SUMMARIES.

« I. — The unfavourable financial po- « sition of most Railways, as a result, in « particular, of ill-regulated competition « between methods of transport, makes it « especially necessary to find, in every « field, simplified operating methods « leading to savings.

« Simplification measures may be the « result of :

« — either lightening of the legal obli- « gations imposed on the Railways,

« — or, within the frame of the legal « obligations, a rational organisation of « the working in order to bring it in « line with the actual requirements of « the various services.

« II. — In order to facilitate the in- « vestigations into the savings to be real- « ised and to obtain more easily from « the public authorities some relief from « the legal obligations, it appears inte- « resting to classify the lines, according « to the density and kind of traffic, into « main lines» and « secondary lines », to « which different operating methods « should apply as a matter of principle.

« In the case of certain lines or groups « of lines, it proves interesting to draw « up balance sheets clearly showing the « cost prices and the deficit.

Main lines.

« III. — Simplification of the working « on main lines should be sought in the « field of the fixed installations and the « working conditions of the staff.

« IV. — A systematic revision of the « buildings and tracks used for the oper- « ation may lead to some of them being « dispensed with.

« V. — The preponderating part play- « ed by staff expenses in railway budgets

« should call, as regards installations, « for such solutions as might allow staff « reductions to be made, viz. :

« — equipping lines carrying heavy « traffic with the automatic block;

« — bringing all the point and signal « operating mechanisms of a station into « a central signal box;

« — equipping large mashalling yards « on modern lines, in order to transfer « thereto the work done in neighbouring « stations;

« — reducing the expenditure on level « crossing keepers;

« — putting certain signal boxes or « block signals out of service during pe- « riods when they are unnecessary.

« VI. — Particular value is attached to « measures tending to proportion as ex- « actly as possible the staff employed to « the actual service requirements :

« — by using auxiliary labour as « standby staff;

« — by temporarily transferring staff « from one department to another;

« — by contracting out certain work « which does not directly affect the « working safety.

« VII. — As regards stations of small « importance, the question should be in- « vestigated as to whether they should « still be served by rail, or are to be « served by road, or again, whether they « should preferably be closed for all or « part of the traffic.

« In such stations, economies can fur- « thermore be obtained :

« — by having the duties affecting the « working safety and other duties carri- « ed out by the same men, or single « man;

« — by discontinuing all safety mea- « sures to be carried out by the station « staff; the station can then be managed « by a person not on the permanent « staff, whose presence will be needed a « few hours per day, the remaining du- « ties being carried out by the staff of « passing trains.

VIII. — It is generally possible to ob- « tain considerable savings on the travel- « ling staff.

« The driving staff can be reduced to « one man, particularly on electric loco- « motives or internal-combustion or ex- « plosion engines, provided such devices « as the « dead-man » be used, or an- « other employee can intervene in the « case of incapacitation of the driver.

« The train staff (conductor, guard) « can be reduced to one man, or even « completely dispensed with in the case « of short trains.

« Duties affecting the safety are then « carried out by the driving staff; such « obligations should then be of a parti- « cularly simple kind, and it would be « interesting to draw up the regulations « accordingly.

Secondary lines of main line systems and secondary railways.

« IX. — Some Railways have found ad- « vantage in having some of their secon- « dary lines worked by light railway « Companies, whose staff is better used « to simplified working methods than « the staff of the main-line railways.

« X. — Extreme simplification of the « safety plant is possible on a secondary « line, in particular the suppression of « most of the signals and interlockings.

« The regulations governing the opera- « tion of the line should also be simpli- « fied and adapted to the nature of the

« traffic and its density : the staff at all « stations can be reduced as a consequence or even completely dispensed « with, the responsibility as regards « train running (meetings, overtaking) « resting with the train staff, under the « supervision of a single controller for « the whole line.

« XI. — The rules in the matter of level crossing keeping can be relaxed :

« — either by increasing the number « of crossings without barriers,

« — or by limiting the periods during « which crossings are watched.

« Such steps should not, however, result in unfavourable speeds of passen« ger trains.

« *General remark.*

« XII. — The application of all the « abovementioned simplification measu« res will relieve the budgets of rail« way undertakings, but will not be able « to put an end to their unfavourable « position if the Public Authorities do « not endeavour to simplify in a general « way the legislation on transport, in or« der to better adapt it to the require« ments of the railways and obtain ra« tional co-ordination of all methods of « transport ».

[385 (06 .111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association

Meetings held by the Permanent Commission in Brussels (6-8 July, 1939).

In addition to its annual Meeting, the Permanent Commission of the International Railway Congress Association held in Brussels, on the 6th, 7th and 8th July, 1939, special Meetings which were attended not only by most of its Members, but also by a number of their Assistants, i. e. Engineers and High Officials of the large Railway Systems. The agenda included the examination of two questions of general and present-day interest for the Railways :

« I. Methods used to speed up passenger trains and the resulting expenditure. In particular, operating by means of railcars and the financial results obtained by this method.

« II. — How should the problems of simplifying the working be considered, in the future, in the interest both of the public and of the railways ? »

The list reproduced — as *Appendix 1*, pages 917 and 918 of this *Bulletin* gives the names of all the Members of the Permanent Commission and their assistants, who attended the technical Meetings.

A Meeting of the Permanent Commission was held first of all in the Conference Room at the Headquarters of the Belgian National Railways Company, rue de Louvain, Brussels. A short account of this Meeting, presided over by Mr. RULOT, General Manager of the Belgian National Railways, is given hereafter.

On opening the Meeting, Mr. RULOT paid a tribute to the memory of two Members of the Permanent Commission who passed away since the 1938 Meeting: Mr. Clément COLSON and Sir Henry FOWLER.

Mr. Clément COLSON, Member of the Institut de France, General Inspector of the Bridges and Highways Department, Honorary Vice President of the French Council of State, Member of the French Railway High Council, died in March 1939, and was one of the oldest Members of the Permanent Commission, being elected in 1895.

Mr. Colson was Vice President of the Executive Committee, and had retired in 1935, when he was appointed Honorary Member of the Permanent Commission in recognition of his outstanding services to the Association.

SIR HENRY FOWLER, former Chief Mechanical Engineer, London Midland and Scottish Railway, and later Assistant to Vice President for Research and Development, of the same Company, died on October 16th, 1938.

Sir Henry Fowler was a Member of the Permanent Commission since 1925 and took an active part, as General Secretary,

at the London (1925), Madrid (1930) and Cairo (1933) Congresses.

Obituary notices recalling the carreer of these two late Members were published in the *Bulletin* of the Railway Congress.

The Gentlemen whose names are given hereafter were elected Members of the Permanent Commission in the place of Members who resigned :

Mr. O. V. BULLEID, Chief Mechanical Engineer, Southern Railway (Gt. Bn.);

Mr. SIKAMA, Manager of the Berlin Office of the Japanese Government Railways;

Mr. BELL, India Office;

Mr. LECLERC DU SABLON, Directeur du Service des Approvisionnements, Commandes et Marchés, French National Railways Company;

H. E. TARRAF ALY BEY, Under Secretary of State, Ministry of Communications, Egypt;

Mr. PORCHEZ, Directeur du Service Central des Installations fixes, French National Railways Company;

Mr. NONI, General Manager, Railway Department, Ministry of Public Works of the Argentine Republic;

Mr. GOUDRIAAN, President, Netherlands Railways Company;

Mr. STANIER, Chief Mechanical Engineer, London Midland and Scottish Railway;

Mr. NEWTON, Chief General Manager, London and North Eastern Railway.

In addition, the three vacant seats of the German Delegation on the Permanent Commission were allotted to the following Gentlemen, at the suggestion of the Reichsbahn :

Mr. Wilhelm KLEINMANN, Staatssekretär;

Dr. Ing. eh. Max LEIBBRAND, Ministerialdirektor; and

Mr. Werner BERGMANN, Ministerialdirektor.

Finally Mr. LE BESNERAIS proposed Mr. Berthelot, Assistant General Manager, French National Railways Company, who was elected in the place of Mr. SURLEAU who had resigned.

SIR NIGEL GRESLEY, Chief Mechanical Engineer, London and North Eastern Railway, Member of the Permanent Commission, was elected as Member of the Executive Committee, at the same Meeting, in the place of SIR RALPH WEDGWOOD.

The Meeting examined and approved the statement of receipts and expenditure for the year 1938 and the provisional budget for 1939, and fixed the variable part of the yearly contribution of the affiliated Administrations at 0.07 gold-franc per kilometre of line worked, the maximum laid down by the rules being 0.20 gold-franc.

The Permanent Commission then examined the proposals submitted by the German Delegates in connection with the organisation of the 14th Session, to be held in Berlin, in 1941.

The Local Organising Committee for this Session is in process of formation and will include high personalities such as the President of the Reichsbahndirektion, Berlin, several representatives of the City of Berlin, the Managers of the « MER » and Mitropa, a representative of the Congress-Zentrale, etc.

It was agreed that the best time to hold the Berlin Congress would be the second half of June, and the Meeting approved a proposal to hold the Session from the 9th or 10th June, 1941, to the 21st or 22nd of that month.

The list of Questions to be placed on the Agenda of the 14th Session was then discussed and finally adopted. This information is published as *Appendix 2*,

pages 919 and 920 of this issue of the *Bulletin.*

It was also decided that the Executive Committee would without delay take the necesssary steps for the appointment of the Officers to be entrusted with the task of drawing up reports on the proposed questions.

The Assembly also formed the Bureau of the technical Meetings which were to be held on July 6th, 7th and 8th, as follows :

FIRST SECTION.

Methods used to speed up passenger trains and the resulting expenditure.

In particular, operating by means of rail-cars and the financial results obtained by this method.

President : Mr. Le Besnerais.

Vice Presidents : Dr. Ing. Dorpmüller.
Mr. Velani.

Principal Secretary : Mr. Chantrell.

Secretaries : Mr. Hennig.
Mr. Beresford.

SECOND SECTION.

How should the problems of simplifying the working be considered, in the future, in the interest both of the public and of the railways ?

President : Sir H. Nigel Gresley.

Vice Presidents : Mr. Etter.
Mr. Goudriaan.

Principal Secretary : Mr. Minsart.

Secretaries : Dr. Sauer.
Mr. Dubus.

The Members of the Permanent Commission were informed of the changes which occurred in the membership of the Association. This is merely a question of the resignation of five small Systems whose activity has been reduced, or which have been amalgamated with other Companies :

	Km.	*(Miles)*
Helsingborg - Hessleholms Railway.	122	*(76)*
Kalmar-Nya Railway . . .	195	*(121)*
Société Nationale de Chemins de fer en Colombie	252	*(157)*
Compagnie Générale de Chemins de fer et Tramways en Chine	621	*(386)*
Ferrovie Torino-Nord . .	59	*(37)*
	1 249	*(777)*

On the other hand, the Meeting was acquainted with the financial position of the Association as it appeared on the 1st July, 1939.

Finally the President informed the Assembly that an invitation had been received from Mr. Velani, General Manager of the Italian State Railways, and Member of the Permanent Commission, to hold a meeting of the said Commission in Rome, in 1942.

This proposal was warmly welcomed, and it was decided that one or two questions would be placed on the agenda for discussion on that occasion. These questions will be selected in the course of the next Meeting of the Permanent Commission, in 1940.

* * *

The technical Meetings took place in the rooms of the Faculty of Applied Sciences at the University of Brussels, the free use of which had been granted to the Association.

These Meetings began on July 6th, at 2.30. The respective sections made themselves acquainted with the special accounts drawn up by the Special Reporters on the two questions brought up for discussion, and interesting debates followed, in which many Delegates representing the principal Railway Systems took part.

On the following day, July 7th, the

work was resumed and summaries were discussed, and proposed for submission to the Permanent Commission at the Plenary Meeting to be held on July 8th.

This Meeting began at 9.30 and was attended by all the Members of the Permanent Commission and their Assistants.

The Assembly, which was presided over by Mr. RULOT, examined and discussed the summaries put forward by the Bureau of each Section and final texts were drawn up and unanimously approved.

These summaries are reproduced on pages 907 to 912 of this issue of the *Bulletin*.

* * *

On July 6th, the Belgian Government invited the Members of the Permanent Commission and the ladies accompanying them, to a formal dinner presided over by the Minister of Communications.

The opening speech was delivered by the Minister who praised the work of the Association, and LORD ROCKLEY, the Senior Member of the Association, replied on behalf of the guests.

On July 7th, Delegates were invited to visit the work now proceeding on the Nord-Midi Railway Junction, at Brussels, and were able to witness the progress made in connection with such work in particular as regards the driving of the tunnels in the centre of the City, and the alteration work in progress at the Brussels-Nord and Brussels-Midi Stations.

On the same day, the Belgian National Railways Company invited all the Delegates who attended the Meetings to a dinner, presided over by the Belgian Minister of Communications, assisted by the President of the Executive Committee of the Belgian National Railways Company, and its General Manager, Mr. RULOT.

The toast to the Heads of the States represented at the Congress was proposed by the Belgian Minister of Communications, and Dr. Dorpmüller, German Minister of Communications, replied by proposing a toast to the King of the Belgians.

Speeches were delivered by Mr. RULOT and by Mr. LE BESNERAIS, General Manager of the French National Railways Company, and Vice President of the Executive Committee of the Association.

The gathering, enhanced by the presence of many ladies, was very lively and most cordial.

Finally, on Saturday 8th, and Sunday 9th July, a trip from Brussels to Liége and Spa was organised in honour of the Delegates and the accompanying ladies.

A special train leaving Brussels-Nord at 2 o'clock took the party to Liége-Guillemins, where the guests took their seats in motorcars to visit the Eupen Reservoir Dam under construction, then the Gileppe Dam and the picturesque regions of the Fagnes, and finally Malmédy via the culminating point of Belgium, the Baraque Michel, the Warche Dam being also met en route. This run ended at Spa where the Delegates arrived in the evening.

The next morning the Spa Town Council welcomed the Delegates and the ladies at the Bathing Establishment, where they attended a short medical lecture on the origins and advantages derived from the various systems of cures which made Spa famous; a detailed visit of the installations followed.

Finally, after the lunch offered by the Nord-Belge Railways, at Spa, the party went by special train to Liége where they visited the International Exhibition. In the course of this visit they were invited to witness a performance of the « Jeu de Liége ».

In the evening some of the Delegates returned to Brussels, while others went back to their own Country, carrying with them pleasant memories of their trip.

t of Members and their Assistants, who attended the Meetings

embers of the Permanent Commission.
sistants to Members of the Permanent Commission.

H. **Barnes**, General European Agent, Pennsylvania Railroad Company.

. **Bell**, India Office.

V. **Bulleid**, Chief Mechanical Engineer, Southern Railway (Great Britain).

tiau, Secrétaire général au Ministère des Communications (Belgium).

** **De Droog**, Directeur général de la Direction Supérieure des Services de Transports Concédés, Ministère des Communications (Belgium).

** **Dugnoille**, Ingénieur en chef-Directeur à la Direction Supérieure des Services de Transports concédés, Ministère des Communications (Belgium).

Costa **Couvreur**, Secrétaire général au Ministère es Travaux Publics et des Communications Portugal).

** **de Azevedo Nazareth de Souza**, Chef du Mouvement, Compagnie des Chemins de fer Portugais (Portugal).

** **Ramalho**, Directeur général des Chemins de fer au Ministère des Travaux Publics et des Communications (Portugal).

Ruffi de Pontevès, Inspecteur général des Mines, Directeur du Contrôle du Travail du Personnel es Chemins de fer et des Transports, Ministère des Travaux Publics (France).

Spirlet, Inspecteur général des Chemins de fer 1 Nord-Belge (Belgium).

** **de Wasseige**, Ingénieur de la Voie, Chemins de fer du Nord-Belge.

** **Lambrecht**, Ingénieur principal de l'Exploitation, Chemins de fer du Nord-Belge.

Ing. eh. Julius **Dorpmüller**, Reichsverkehrsminister, General Direktor, Deutsche Reichsbahn Germany).

** Dr. **Sommer**, Ministerialrat, Deutsche Reichsbahn.

r, Président de la Direction générale des Chemins de fer Fédéraux (Switzerland).

** **Ballinari**, Chef principal de l'Exploitation, Chemins de fer Fédéraux (Switzerland).

** **Müller**, Ingénieur, Chef de la Division de la Traction et des Ateliers, Chemins de fer Fédéraux (Switzerland).

lain, Ingénieur en chef à la Société Nationale es Chemins de fer belges (Belgium), General ecretary, International Railway Congress Association.

** **De Blieck**, Ingénieur en chef au Service du Matériel de la Société Nationale des Chemins de fer belges.

** **Franckson**, Ingénieur en chef au Service du Matériel de la Société Nationale des Chemins de fer belges.

* **Goudriaan**, President des Chemins de fer Néerlandais (Netherlands).

* Sir H. Nigel **Gresley**, C. B. E., D. Sc., Chief Mechanical Engineer, London & North Eastern Railway.

** D. R. **Edge**, Assistant to the Chief Mechanical Engineer, London & North Eastern Railway.

** E. T. **Thompson**, Mechanical Engineer, London & North Eastern Railway.

* Sir Harold **Hartley**, Vice-President, London Midland and Scottish Railway Co.

** C. E. **Fairburn**, Deputy Chief Mechanical Engineer and Chief Electrical Engineer, London Midland & Scottish Railway.

* R. J. **Harvey**, Consulting Engineer to the Government of New Zealand.

* **Jacobs**, Directeur général de la Société Nationale belge des Chemins de fer Vicinaux (Belgium).

** **Valcke**, Directeur à la Société Nationale belge des Chemins de fer Vicinaux.

* **Jezierski**, Inspecteur ministériel au Ministère des Communications (Poland).

** **Dijakiewicz**, Chef de Division au Ministère des Communications (Poland).

* Dr. **Kittel**, Ministerialdirigent, Deutsche Reichsbahn (Germany).

** **Hamel**, Amtstrat Deutsche Reichsbahn.

* **Knutzen**, Directeur général des Chemins de fer de l'Etat (Denmark) (*prevented*).

** **Terkelsen**, Directeur en chef de l'Exploitation et du Personnel, Chemins de fer de l'Etat (Denmark).

* **Kradolfer**, Directeur de l'Office Fédéral des Transports de la Confédération Suisse (Switzerland).

* **Lamalle**, Directeur général adjoint à la Société Nationale des Chemins de fer belges.

* **Láner de Orsova**, Secrétaire d'Etat, Président de la Direction des Chemins de fer Royaux de l'Etat (Hungary).

* **Le Besnerais**, Directeur général de la Société Nationale des Chemins de fer Français (France).

* **Lemaire**, Directeur du Service de la Voie de la Société Nationale des Chemins de fer belges (Belgium).

** **Campus**, Ingénieur en chef au Service de la Voie de la Société Nationale des Chemins de fer belges.

** **Willaert**, Ingénieur en chef au Service de la Voie de la Société Nationale des Chemins de fer belges.

* **Lévy**, Directeur du Service Central du Matériel à la Société Nationale des Chemins de fer Français (France).

** **Hébert**, Ingénieur en chef, Chef du Service du Matériel et de la Traction de la Région de l'Ouest, Société Nationale des Chemins de fer Français.

** **Schürr**, Ingénieur en chef, Chef de la Division de la Traction du Service du Matériel et de la Traction de la Région du Nord, Société Nationale des Chemins de fer Français.

* **Macovei**, Directeur général des Chemins de fer Roumains (Rumania).

** **Bucur**, Sous-Directeur à la Direction du Mouvement des Chemins de fer Roumains.

** **Misicu**, Sous-Directeur à la Direction d'Etudes des Chemins de fer Roumains.

* **Mange**, Président de l'Union Internationale des Chemins de fer (U. I. C.).

* **Marguerat**, Directeur des Compagnies Viège-Zermatt, Furka-Oberalp, Gornergrat et Schöllenen (Switzerland).

* **Nachtergaele**, Directeur du Service de l'Exploitation de la Société Nationale des Chemins de fer belges (Belgium).

** **Demaret**, Inspecteur principal à la Société Nationale des Chemins de fer belges.

** **Dessent**, Ingénieur en chef à la Société Nationale des Chemins de fer belges.

* **Newton**, Chief General Manager, London & North Eastern Railway.

* **Porchez**. Directeur du Service Central des Installations Fixes à la Société Nationale des Chemins de fer Français (France).

** **Bastien**, Ingénieur en chef, Chef de la Division de l'Entretien du Service de la Voie et des Bâtiments de la Région du Sud-Est, Société Nationale des Chemins de fer Français.

** **de Nerville**, Ingénieur en chef au Service de la Voie et des Bâtiments de la Région de l'Est, Société Nationale des Chemins de fer Français.

* The Right Hon. **Lord Rockley**, P. C., C. B. E., Director, Southern Railway (Great Britain).

* **Rulot**, Directeur général de la Société Nationale des Chemins de fer belges (Belgium), President of the International Railway Congress Association.

* Dr. **Sauer**, Ministerialrat, Reichsverkehrsministerium (Germany).

* **Sikama**, Secretary, Ministry of Railways (Japan), Manager of the Berlin Office of the Japanese Government Railways.

** **Satake**, Chief Engineer, Berlin Office of Japanese Government Railways.

*The Right Hon. **Lord Stamp**, G. C. B., G. B. Chairman and President of the Executive, L don Midland & Scottish Railway.

** W. K. **Wallace**, Chief Civil Engineer, Lon Midland & Scottish Railway.

* W. A. **Stanier**, Chief Mechanical Engineer, Lon Midland & Scottish Railway.

* T. C. **Swallow**, Advisory Engineer, Office of High Commissioner for the Union of South Afr

* H. E. **Tarraf Aly Bey**, Under Secretary of State, nistry of Communications (Egypt).

* **van Marle**, Inspecteur-Generaal van het Verk Rijksverkeersinspectie (Netherlands).

* **Velani**, Directeur général des Chemins de fer l'Etat (Italy).

** **Cuttica**, Inspecteur en chef supérieur, C mins de fer de l'Etat (Italy).

** **Farnè**, Direction des Chemins de fer de l' (Italy).

** **Tosti**, Ingénieur, Chef de Service, Chem de fer de l'Etat (Italy).

* **Verkoyen**, Directeur du Service du Matériel d Société Nationale des Chemins de fer be (Belgium).

* **Yoyitch**, Directeur général adjoint des Chemins fer de l'Etat (Jugoslavia).

** **Djourkovitch**, Chef du Service de la Trac à la Direction Générale des Chemins de de l'Etat (Jugoslavia).

REPORTERS :

Desorgher, Secrétaire technique de la Direction nérale de la Société Nationale des Chemins de belges (Belgium).

Dumas, Directeur attaché à la Direction Géné de la Société Nationale des Chemins de fer F çais (France).

Fesser, Reichsbahndirektor, Deutsche Reichsb (Germany).

Goursat, Directeur du Service Central du Mo ment à la Société Nationale des Chemins de Français (France).

** **Dreyfus**, Chef adjoint du Service de l' ploitation de la Région du Sud-Ouest, ciété Nationale des Chemins de fer F çais.

** **Tuia**, Chef du Service de l'Exploitation Région du Sud-Est, Société Nationale Chemins de fer Français.

F. E. **Harrison**, Engineer (North Eastern A London & North Eastern Railway.

Lo Balbo, Président du Conseil d'Administra Tramways Dogliani-Monchiero (Italy)

Rohde, Ministerialrat, Deutsche Reichsbahn (many).

T. W. **Royle**, Chief Operating Manager, Lo Midland and Scottish Railway.

Stroebe, Ministerialrat, Deutsche Reichsbahn (many).

List of questions selected for the Agenda of the 14th Session (Berlin, 1941).

First Section :

WAY AND WORKS.

I. — Better riding of vehicles at high speeds :

(a) Equipment and maintenance of the track;

(b) Rolling stock.

II. — Welded bridges. Use of welding in the construction of railway bridges.

Regulations : quality of the parent and weld metals; permissible stresses; tests and control; non-destructive examination of the welds; choice of the types of assembly and if need be of the type of bridge.

Welding processes and programme; measures to be taken to reduce deformations and residual stresses.

III. — Sleepers :

(a) Different types;

(b) Maintenance methods;

(c) Financial comparison.

Second Section :

LOCOMOTIVES AND ROLLING STOCK.

IV. — New tendencies in the construction of the steam locomotive, especially from the point of view of the use of steel fireboxes and individual axle drive.

V. — Recent progress and opinions on the future of the internal-combustion (petrol and diesel) engine for traction purposes.

Locomotives, railcars, locotractors.

VI. — Improved braking methods for high-speed trains.

Third Section :

WORKING.

VII. — Evolution of the rates structure. New rating formulæ.

Passenger traffic :

Policy of reduced fares. Cheap touring. Journeys at inclusive rates.

Goods traffic :

Transport at agreed rates.

New rating facilities introduced recently for passenger transport as a result of the higher train speeds over short and average distances.

VIII. — Ordinary goods traffic in complete wagon loads.

Organisation of the service to and from intermediate stations in order to increase the output of the lines and rolling stock on lines carrying heavy and average traffic.

Advisibility of making use, as required, of heavy or light trains, pick-up trains, distributing trains, shuttle services, local rakes — Utilisation of locotractors for shunting in small stations along the line and for certain shunting operations in the large stations.

IX. — Level crossing accidents, elimination of crossings, etc. and question as to who should legitimately bear the cost of building bridges and other structures

and the approaches thereto made necessary by such elimination.

Fourth Section :

GENERAL.

X. — Comparison of the methods of calculating the cost price of transport. — Preparation of comparative balance sheets in order to study the new methods of traction : electrification, use of diesel locomotives and railcars.

XI. — General organisation of the stores department (reduction to the minimum of stocks; cartels or trusts; watching the purchase prices, etc.).

XII. — Apprenticeship and training of the staff.

Fifth Section :

LIGHT RAILWAYS AND COLONIAL RAILWAYS.

XIII. — How should a group of secondary and local lines be organised in order to obtain the most economical operation ?

(a) Is it advisable to centralise or decentralise the services ?

(b) Should the methods of organisation adopted for lines of general interest be retained (separate departments in charge of the operating, locomotives and rolling stock, and permanent way and works) or is it preferable to have direct co-operation between the different services in the lower ranks ?

(c) Carrying out the transport contract in practice. Operations : acceptance, delivery, transport properly speaking and handling, maintenance; operating schedules; standardisation; local grouping; staff.

XIV. — Simplification of the accounts and of the charges on secondary lines and lines carrying little traffic.

[625. 143. 2 (.43)]

The production of martensitic rails

(*The Railway Gazette.*)

A description of the methods used by the Eisenwerk Gesellschaft Maximilianshütte, of Sulzbach-Rosenberg, Bavaria, in the production of rails with a surface hardness of over 400 Brinell, and of their physical characteristics and wearing capacity.

During the two decades which have succeeded the war of 1914-1918, considerable progress has been made in Continental countries in the technique of rail manufacture, as is evident to those who have studied the proceedings of the International Rail Congress held in 1928, 1933, 1936, and last year. In particular much attention has been paid to the production of reliable steels to meet track conditions where the wear of rails is exceptionally heavy. The principal developments in this direction have been in the realm of alloy steels, in the fusion of hard alloys with rail steel of normal quality by special methods of casting ingots in which both qualities are combined (the hard quality for the head of the rail and the normal steel for the web and foot), the production in electric furnaces of pearlitic manganese steel, and, lastly, by heat-treatments.

It is significant of the extent of this development that as far back as 1933 the Swiss Federal Railways, which on some main lines, such as the Gotthard, carrying heavy traffic over steep gradients with almost unbroken sharp curvature, have extremely severe rail wear conditions, should have been specifying steels with as great a surface hardness as 380 to 450 Brinell on the head for such places. Compound rails were required to show a hardness of 300 to 400 in the alloyed head, but only 140 to 170 in the foot, and electrically-refined manganese steels not less than 270 Brinell. The chemical compositions required in these three qualities were carbon from 0.40 to 0.45 per cent, and manganese from 0.9 to 1.0 per cent. In the heat-treated rails, carbon about 0.55 per cent. and manganese about 1.85 per cent. in the manganese rails, and in the compound rails 0.7 per cent. carbon and 0.6 per cent. manganese, together with a suitable alloy in the head, and not more than 0.2 to 0.3 per cent. carbon (a mild steel) in the foot. In applying the impact bending test, the compound rail was required to deflect at least 100 mm. (3 15/16 in.) and the other two qualities at least 60 mm. (2 3/8 in.) under the falling weight without fracture. By 1936 these requirements of the Swiss Federal Railways had been somewhat modified, doubtless in order to reduce the risk of fracture, the Brinell hardness required on the head of rails which had been subjected to the martensitic treatment being from 350 to 400, while compound rails had to show 300 to 350 Brinell hardness on the running surface, and rails that had undergone the sorbitic treatment 280 to 330 Brinell.

Type of steel treated.

The most extreme of the Continental heat treatments of rails is that which has been developed at the Sulzbach-Rosenberg works in Eastern Bavaria, Germany, of the Eisenwerk-Gesellschaft Maximilianshütte, and on one of the works visits connected with last year's International Rail Congress at Düssel-

dorf we were able to see this process in operation at Rosenberg. The process by which the rail steel is produced at this works is the Thomas, or basic Bessemer (as is the general practice in Germany and France), and the treatment consists in quenching the entire rail-head, immediately after the rail has left the mill, in order to produce a structure of martensitic quality in the wearing part of the head. Originally the steel used for this purpose was a straight carbon steel with a fairly normal analysis — for the basic Bessemer process — containing about 0.40 per cent. carbon, but latterly a new type of steel has been developed containing only 0.32 to 0.36 per cent. carbon; this is in combination with 0.70 to 0.90 per cent. silicon and 0.70 to 0.90 per cent. manganese; sulphur and phosphorus are normal at about 0.05 per cent. and 0.06 per cent. respectively. The effect of this changed composition is to give greater liberty in the quenching without the risk of producing fissures in the rail-head, and whereas in Great Britain the relatively soft untreated foot of the rail might be expected to give difficulty in service traffic conditions by excessive chair-galling, or indentation of the rail-foot (equally with the mild steel foot of the compound rail), the considerably greater bearing area of the flange rail on its sole-plate, as compared with the bull-head rail on its chair-seat, is adequate in Continental countries to guard against foot troubles arising out of this chemical composition. Further, in the standard « K » type of track used on the German State Railways, the compressed poplar slip between the foot of the rail and the sole-plate serves to protect the former. When this special low carbon silicon steel is being made it is necessary to treat 100 per cent., of the mill output, as the wearing capacity of untreated steel of this analysis would be inadequate; and for the same reason the maker has not the option of treating only middle and bottom rails from the ingot, should he so desire.

Rolling and quenching.

At the Maximilianshütte works ingots of approximately 3 tons weight were being used, and the rail section in course of rolling and treatment was the 49 kgr. per m. (98 lb. per yd.) standard section of the German State Railways. After 20 passes in the blooming mill, and 9 through the roughing and finishing mills, a bloom is produced of sufficient length to cut, after cropping, to one 30 m. (98 ft. 5 in.) and one 15 m. (49 ft. 2 1/2 in.) rail, together with an additional 1 1/2 m. or slightly less on the rail-end to provide for the bending tests. The shorter rail is cut from the top of the ingot, and the longer rail from the bottom; both are subjected to quenching treatment simultaneously. A jet of steam under considerable pressure is directed on the rail at the last two passes through the mill — a common practice in Germany — in order to clean the surface of scale. In the case of the 30 m. rail, after it has been cut to length at the hot-saw, it is inverted, and a frame of relatively light but rigid construction is lowered on to it, from which are suspended eighteen sets of clamps at equidistant spacings. These firmly grip the foot of the rail, which is thus held with the head downward exactly horizontal during the dipping process. The temperature of immersion, which is pyrometrically checked in the case of each rail, is from 880 to 900° C. The 15-m. rail is similarly treated, but requires only nine sets of clamps to hold it.

Dipping takes place in a long and narrow tank of running water, in which the rail head, but no part of the fishing or the web, is immersed for its entire length. The duration of the immersion at the time of our visit was 68-69 sec. per rail; slight variations of the quenching time are made to meet variations in the

carbon contents of different casts. The rail is then withdrawn from the tank and lowered on to the mill floor; immediately it is released from the frame, it begins to curve by contraction of the head into a considerable camber. Dogs attached to wire ropes are then attached to the outer ends of the rail, which is drawn by a steady tension round a curved frame into a counter-camber. The total amount of counter-camber which by experience has been found necessary with 30-m. treated rails is 5.40 m. (17 ft. 9 in.). The curved frame round which the rail is drawn is to ensure an even curvature, but a disadvantage of this method, as compared with the cambering machines that are in use in British rail-mills in connection with the sorbitic treatment of rails; is that variations of camber according to rail section make it necessary to provide a different frame for every section treated, whereas the British cambering machines provide for unlimited variation of camber. After cambering, each martensitic rail is left to cool out normally, and while doing so gradually straightens itself, the amount of cold-straightening finally required, in view of the drastic nature of the treatment, being surprisingly small. The final operation, apart from ending to length and drilling, is that of passing the rails through a very fine modern roller straightening machine, with eight heavy rollers, four upper and four lower; the time required for each 30 m. rail is a little under 1 1/2 min., and no further hand-straightening is required, the straightness of the rails being practically perfect.

Falling weight tests.

The effect of the treatment is to provide the rail-head with a hardened « case » of martensite, extending round the top of the head and down the two sides, so that side-cutting wear on curves is as well provided for as head wear on the straight. The back-flow of heat from the foot and web of the rail to the head, after the quenching, provides for some annealing and for a smooth transition from the martensitic structure of this outer layer through sorbite, troostite, and ferrite to the normal pearlite-ferrite structure of the web and foot, which helps to safeguard the rail section as a whole from tendencies to fracture in shock condtions. The centre of the head, also, is but little harder than the lower part of the rail. On our visit, falling weight tests were applied to rails which had just been treated; in one case test-pieces of rail of the customary length of a little over 1 m. were laid head upwards on supports 1.00 m. (3 ft. 3 1/2 in.) apart, and sustained in succession blows of a metric tonne weight, first from 5 m. (16 ft. 5 in.) and then seven times in succession from 3 m. (9 ft. 10 in.) without fracture, at the end of which time it had deflected 16 cm. (6 1/4 in.). It may be remarked that this test, although sufficient to meet the requirements of the German State Railways, is easier than the B. E. S. A. standard test in Great Britain, which in the case of the 100-lb. flat-bottom B. S. section requires the slightly heavier ton weight (2 240 as compared with 2 204 lb.) to fall from 26 ft. 6 in. (8.10 m.), or in the case of the 95-lb. flat-bottomed section from 25 ft. (7.60 m.) without fracture of the rail; with the 95-lb. and 100-lb. bull-head sections the B. E. S. A. requirement is successive blows from 7 ft. (2.13 m.) and 20 ft. (6.10 m.) without fracture. The supports of the rail in the B. E. S. A. tests also are 3 ft. 6 in. instead of 3 ft. 3 1/2 in. apart. No relaxation of this British test is permitted with heat-treated or alloy rails; and in addition the Sandberg regulated sorbitic rails are tested head downwards, with the treated part of the rail in tension instead of compression — an even more severe test. Information is not available as to how a martensitic rail would behave under tests of this severity, but an illustration

in a report on these rails prepared in 1936 by Professor M. Ros indicates that a rail of this quality subjected to testing head downwards sustained a relatively small deflection before fracture occurred.

Hardness and bending tests.

Finally a polished section of one of the treated rails was subjected to the Brinell test, and impressions made 4.5 mm. (a bare 3/16 in.) below the head gave Brinell readings of 426 in the top left-hand corner, 423 in the centre, and 420 in the top right-hand corner. In the centre of the head, however, the reading was no more than 235 Brinell, which is but little above the normal hardness of the steel, about 200 Brinell. In general, the martensitic high silicon rail shows a hardness of between 360 and 440 round the head and to a depth of 9/32 in. below the surface, corresponding to a tensile strength of between 82 and 98 tons per sq. in., while the web and flange give a Brinell reading of 195 to 220, corresponding to a tensile strength of 44 to 49 tons per sq. in. In the static bending test, a length of 49-kgr. per m. (98 lb. per sq. in.) flat-bottomed rail, laid on supports 1 m. (3 ft. 3 3/8 in.) apart, is expected to stand the application of a static load of 100 tonnes, and to deflect not less than 3.95 in., without failure or the development of cracks. Here again, however, the rail is tested head up, with the hardened head in compression and not in tension. Experiments have been conducted in which the ingots used for the manufacture of the martensitic rails have been cast with a centre of mild steel of about 135 Brinell hardness, and the ingots have been rolled in such a way as to bring this core to the centre of the head, but this method is not in general use for martensitic rails.

Since the martensitic treatment was begun at Rosenberg by the Maximilianshütte Company, the German State Railway has taken about 12 000 tonnes of this quality, of which 2 000 tonnes have been of the new high-silicon composition. The party that visited the works at Sulzbach-Rosenberg was also taken by special train to a point on the Berlin-Munich main line, a short distance south of Probstzella, Thuringia, where rails of both qualities were seen in the track. The normal carbon rails had been in the road for ten years, but the silicon rails had been laid recently. The section concerned is a long gradient at 1 in 40, over which most ascending trains require banking assistance, and down which the brakes are constantly in use, owing to sharp curvature. These rails are, however, wearing well, and there are no signs of excessive side-cutting, as was previously experienced with untreated rails; they are laid in both the ascending and the descending tracks. Most of the Maximilianshütte martensitic rails, however, have been laid in electrified suburban lines in the vicinity of Berlin.

Wear experiments in Switzerland.

Extensive wear experiments have also been conducted on the Gotthard main line of the Swiss Federal Railways, both between Amsteg and Gurtnellen, and between Lavorgo and Giornico, where the grade is 1 in 38 1/2 continuously, and the curves vary from 280 to 300 m. (14 to 15 ch.) in radius. Whereas ordinary rails laid in this location in 1927, with a tensile strength of 41 to 44 tons per sq. in., lost 4.57 sq. cm. of their cross section by side-cutting after carrying 17 400 000 tonnes of traffic, between Amsteg and Gurtnellen, and 5.00 sq. cm. between Lavorgo and Giornico, after carrying 23 700 000 tonnes, the corresponding losses of Maximilianshütte martensitic rails, with a tensile strength of 76 tons per sq. in. in the hardened zone of the head, laid in 1928, were 1.99 sq. cm. per 25 800 000 tonnes, and 2.27 sq. cm. per 33 000 000 tonnes respectively;

averaged out, the loss was 1 sq. cm. per 4 270 000 tonnes in the case of the martensitic rails, as compared with 1 sq. cm. per 1 375 000 tonnes in the case of the ordinary rails — an advantage of over 3 to 1 in favour of the former. In comparison with British practice, even in 1928, however, the tensile strength of the ordinary rails in this test was extremely low. The treated rails were of the original straight carbon quality of steel; results are not sufficiently advanced to enable a similar comparison to be made with the high silicon quality, which is of more recent introduction.

Rails of the latter quality since laid in by the Swiss Federal Railways have given the following test results : the hardened zone of the head has shown a yield point of 100 kgr. per sq. mm. (63 1/2 tons per sq. in.), and a breaking strength of 144.6 kgr. per sq. mm. (91.8 tons per sq. in.) in conjunction with an elongation of 3.7 per cent. and a reduction of area of 10 per cent; the untreated steel had a yield point of 39.5 kgr. per sq. mm. (25.1 tons per sq. in.), and broke at 72.4 kgr. per sq. mm. (46.0 tons per sq. in.), with an elongation of 15.9 per cent., and a reduction of area of 49 per cent. Here again the tensile strength of the untreated steel would be, to British standards, on the low side, as breaking strengths in excess of 50 tons per sq. in., with higher average elongations exceeding 17 per cent., are now customary here, and for reasons of chair indentation referred to earlier, this quality of steel might not commend itself to British engineers, though evidently giving no trouble with flat-bottom rails. Details of these Swiss tests are taken from the report previously referred to, by Professor E. M. Ros, Principal of the Materials Testing Laboratory attached to the Swiss Federal Technical College at Zurich, in which a detailed analysis of the physical properties and wear characteristics of these rails was made, and a favourable conclusion was reached as to their wearing capacity and reliability in service. As yet the Sulzbach-Rosenberg works of the Maximilianshütte Company is the only works in Europe at which rails of this particular type are produced.

[621. 134. 5 (.73), 621. 135. 2 (.73) & 625. 214 (.73)]

Methods of lubrication used on the railways of the United States (*)

by J. RIBOUD,

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(Revue Générale des Chemins de fer.)

General considerations.

It is chiefly from the point of view of safe working and maintenance of rolling stock, in addition to that of oil consumption, that the railways are interested in investigations into lubrification methods. These investigations, which concern both the way in which the oil is applied and the quality used, have been actively prosecuted in recent years in all countries, following improvements made to locomotives and rolling stock. Amongst the latest improvements to give rise to a lubrication problem may be mentioned the raising of superheat temperatures, the replacement of ordinary slide valves by poppet and piston valves, and the widespread use of high-speed diesel trains; the refineries have been led to perfect new oils for use with the latter owing to the difficult working conditions to which they have to stand up.

We may also mention the new operating conditions which are not without their repercussion on lubrication, such as the pooling of locomotives, which, by reducing the part taken in maintenance by the individual driver, may lead to the development of the centralised system of lubrication under pressure.

(*) The importance attached to lubrication in railway working is well known. The author of the present article having had occasion in the course of a journey of investigation to look into the question of lubrication on American railways, it appeared to us of interest to give readers a few of the particulars he obtained from the railway companies, oil refineries and manufacturers of lubrication equipment. (Editorial note, *Revue Générale des Chemins de fer*).

The problems encountered in France have also been met with in the United States. The Americans have solved them by methods which are of interest to us, although at times somewhat different from our own. We shall first point out the principal tendencies on the American railways, since the lubrication question is associated therewith.

The most striking progress effected in recent years is certainly the raising of speeds. For instance, a diesel-electric train, the « Denver Zephyr », makes the run of about 1 680 km. or 1 044 miles (a greater distance than that separating Paris from Vienna) from Chicago to Denver in 15 h. 15 m., at an average speed of 109 km. (68 miles) per hour.

Besides such trains as these, of which there are not many as yet, the ordinary steam or electric trains, formerly somewhat slow, have also been accelerated : the « XXth Century » 1 000 t. (984 Engl. tons), between New York and Chicago, covers the distance of about 1 315 km. (817 miles) from Chicago to Albany at an average speed of 97.5 km. (60 1/2 miles) per hour. Steam traction, either with modified or specially constructed locomotives, is now able to complete successfully with the express diesel services; on the Burlington, the Denver Zephyr has recently been taking turns with a light steam train; on the Milwaukee, the Hiawatha trains attain a speed of 170 km. (107 miles) per hour on certain sections of the Chicago-Minneapolis run.

Several railways, such as the Burlington, even appear to prefer the light steam trains to the diesels on account of

their lower cost, and consider that the future lies with them.

The characteristic features of the modern American locomotives are large grate area, high power and high axle load (30 tons). The boiler pressure is of the same order as that found in France and the maximum superheat temperatures slightly lower, being about 375° C. (710° F.). Walschaerts or Baker valve gear is used, actuating piston valves. Cylinder lubrication is effected by pumps, such as the Detroit or Nathan, very similar to our own.

From the quality point of view the Pennsylvania cylinder oils, types similar to which are well known in France, continue to be employed successfully. As is well known, the increase a few years ago in superheat temperatures led to the use of compound oils of high flash point. At present the Americans appear not to wish to push superheat temperatures much beyond 400° C. (750° F.), as in that case new types of oil might perhaps be necessary.

The railways are using hard grease for the heavier types of mechanism, and soft grease for the light ones, applied under pressure with Tecalemit type equipment.

In the axle boxes hard grease has long been used for driving axles, and packing (waste soaked in oil) for carrying axles; the latter arrangement is also generally employed in wagon axle boxes.

Grease and packing type boxes are being replaced in the newest locomotives by roller bearing boxes. The mechanical failures met with at the outset, such as breakage of the cage or races, appear to have all but disappeared, and the railways express themselves satisfied with a device which, despite its high price, has the advantage of being easy to maintain and of eliminating hot boxes.

The locomotives are maintained with the greatest care and the lubrication equipment is inspected periodically. Such measures as these, combined with general pooling of the engines, have enabled them to be utilised in a noticeably better manner, some running 20 000 km. (12 500 miles) per month under normal conditions. On the Santa Fe, for example, certain trains are hauled over 1 000 km. (620 miles) by the same engine, with three successive crews.

In addition to the steam locomotives, the diesel-electric types offer interesting features from the point of view of lubrication and maintenance.

The latter kind of locomotive, in use for some time for shunting work, has proved very successful during the last three years for hauling light trains over long distances.

The Electromotive type of diesel engines, the most widely used, are of the two stroke pattern with a higher power than ours — 900 H.P. — if the two new locomotives for the South Eastern Area be excepted —, a slightly greater weight per horse-power (10 kgr. = 22 lb.) and a lower number of revolutions per minute.

Instead of being emptied away after a certain mileage — 5 000 to 6 000 km. (3 000 to 4 000 miles) — the oil is periodically analysed and only replaced when its characteristics have deteriorated beyond certain limits; this permits of a longer and better use of the oil and a check on the good working of the engine. The maintenance of the latter, including decarbonising, renewal of bearings, etc., is carried out by special gangs during the few hours between runs.

This, necessitating as it does, staff trained specially for the purpose, is quite contrary to American custom and is worthy of note on that account. It explains, quite as much as the good quality of construction used, the exceptional life in service obtained from the engines. On the North Western, the Chicago-Denver run is effected daily by the same train and locomotive, which fre-

quently cover in this way 48 000 km. (30 000 miles) per month. The engines cover 70 000 km. (43 500 miles) without overhaul.

We may note too that in America there is not as great a diversity of types of railcar as in France; the small size railcars, carrying 50 to 100 passengers, so useful to us, especially for accelerated stopping services between the small stations, have been but little developed. The American railways have devoted their attention chiefly to improving facilities between large centres some distance apart, leaving the motorbus to serve the small places.

In the following pages a few details are given about the following items :

— lubrication of steam cylinders (quality of products used, different types of pumps and piston rings);

— lubrication of the motion;

— lubrication of the axle boxes, grease, packing, pads, roller bearings;

— lubrication of diesel engines.

I. — STEAM : CYLINDER LUBRICATION.

Quality of oil used.

For several years now the maximum superheat temperature of American locomotives has been fixed at 380° C. (716° F). and even on the most modern ones this figure is only exceeded incidentally. Locomotive experts in the United States do not appear to wish for any increase, considering the superheat temperature high enough, in view of the degree of expansion obtained on present-day locomotives, which are generally of simple expansion type.

The Pennsylvania cylinder oils are still in general use. They are obtained, as is well known, from selected crude Pennsylvania oils, the light products of which are distilled off down to the paraffin distillate. For high superheat temperatures high flash-point oils are used, often slightly filtered, or extracted from selected crude oils of low asphalt content. These oils are generally compounded to 4 % of lard oil.

Table 1 gives the specifications adopted by certain railways.

To obtain special classes of oil the railways frequently have recourse to well tried suppliers and official specifications form no suitable guide to the oils really used; for this reason we have also included in the table the characteristics of an oil used by the Santa Fe Railway [1].

Generally speaking these oils appear to meet the requirements of the railways.

Pumps.

The gravity type lubricator has been entirely given up for the modern locomotives and been replaced by central multi-pump lubricators, feeding the oil to the various points under pressure.

The types of pump used on the American railways are very similar to those met with on the French railways, the most widely used makes being the Detroit, Nathan, Chicago, and Locomotive Supply.

As is known these devices are gener-

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(1) The American laboratories employ almost the same methods of analysis as the French. Viscosity is measured by the Saybolt apparatus, the indications on which are easily converted to Engler values or cinematic viscosity. To measure the asphalt content 5 cm^3 of oil is diluted in petrol having a density of 0.650, distilled on the A. S. T. M. method between 27 and 65° C. French specification : density between 0.640 and 0.650; distillation between 35 and 50° C.

When diluted, the oil is left to settle in a 100 cm^3 test tube. After 5 to 10 minutes, it may not show any deposit (Pennsylvania). On other railways (Milwaukee), after 24 hours the precipitate may not exceed 5 % of the oil volume, and the weight of the deposit, soluble in chloroform, must be below 0.1 % of the oil weight.

TABLE 1. — **Specifications and characteristics of high-superheat cylinder oils used by the American Railways.**

—	*Pennsylvania.*	*New York Central* (1934).	*Chicago & North Western.*	*Chicago-Milwaukee.*	*Santa Fe.*	*French National Rys. Co's specifications*	
						pure.	compound.
Colour.	...	green	...	green	...	...	...
Density at 15° C. (52° F.)	0.903	0.921 max.	...	...	0.921	...	...
Flash point, in open vessel : ° C. (° F.)	274 (525)	293 (560)	310 (590)	293 (560)	304 (580)	308 (586)	300 (572)
Viscosity at 99° C. (210° F.)	4.3/4.8	4.6 Engler	between 5 and 6 Engler	4.75	4.5	7.5 (mn.) (100° C.)	7.5 (mn.) (100° C.)
Liquefaction : ° C. (° F.)	15 (59)	...	10 (50) max.	15 (59)	15 (59)	...	...
Asphalt content, maximum	...	0.15 %	...	0.1 %	0.015 %	0.5 %	0.5 %
Precipitation	0	...	0 (10 mn)	...	...	...	...
Animal oil content	0	4 % lard oil	0	5 % lard oil	4 % lard oil	...	saponif. index : 2.5 to 10

ally made up of independent elements, each comprising a pump with feed system and delivery input point of its own. All these are fixed on the same main bedplate, which acts as an oil reservoir; the pumps are driven by a central spindle passing through the reservoir and connected to the motion of the engine through a ratchet wheel.

The Detroit A pump.

In the *Detroit* A pattern (fig. 1), the pump is composed of a main pump piece A, which is given an oscillating action, and two fixed opposing pistons, of which the lower (C) has a cross section double that of the upper one (D).

In its upward movement the main portion, or body, draws oil in through a passage inside the piston, into the chamber K, where it is retained by a ball valve. During the downward movement, owing to the difference in the cross sec-

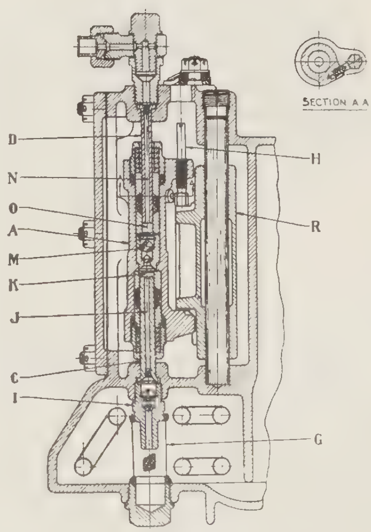


Fig. 1. — Detroit type A pump.

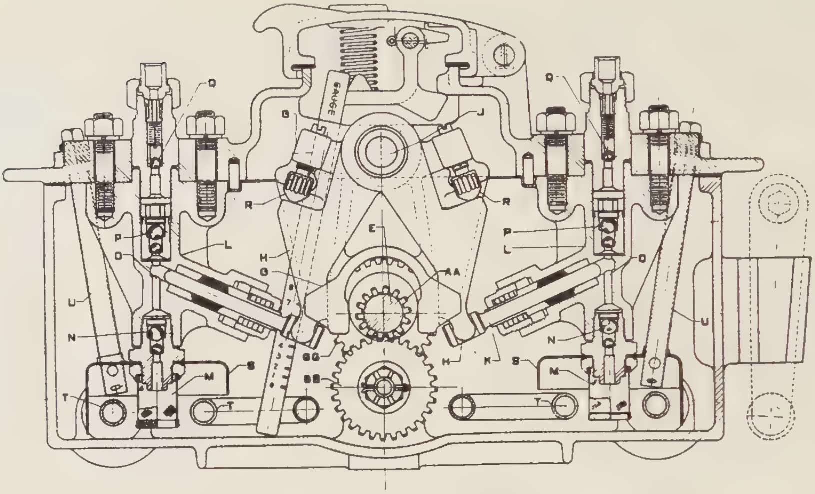


Fig. 2. — Detroit type B pump.

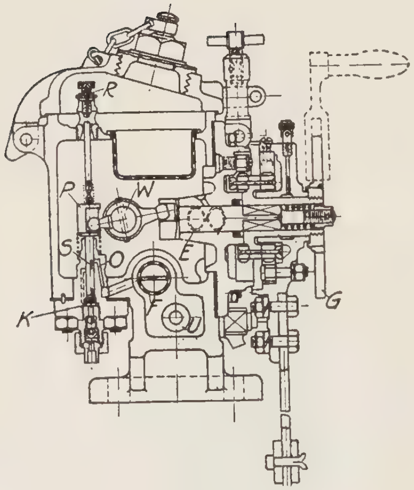


Fig. 3. — Nathan pump.

tions of the pistons, half the oil so drawn in is forced into the lubrication pipes, the other half remaining in the chamber 0, being expelled when the piston rises once more. In this way the oil is fed to the distributing pipes during both the upward and downward strokes of the pump.

The output is regulated by securing the pump body in varying positions with respect to the actuating piston R by means of the screw H.

The elimination of any cessation in the feeding of the oil is specially advantageous at the moment of starting. In the usual pattern of two-stroke pump, as soon as the piston is at the very commencement of the stroke which draws the oil in, the locomotive wheels must make some 20 revolutions before any of it reaches the point where lubrication is needed. On the other hand, these pumps have glands and ball valves and are in consequence distinctly inferior to the modern types with close fitting pistons and distribution valves.

The Detroit B pump.

In this pattern (fig. 2) the centre spindle AA transmits an alternating movement through an eccentric and a forked lever, to 2 oscillating levers H, rotating on a spindle J. This motion is transmitted to the pump pistons through other levers keyed to the same spindle.

The Nathan pump.

The *Nathan* pumps (fig. 3) are similar

to the *Bourdon* LB compressed-air pumps. The rotary movement of the shaft T, by means of a two-fingered rotary piece, imparts an alternating vertical movement and an oscillatory movement around its spindle simultaneously, to the piston B. This double movement ensures the drawing in and forcing out of the oil and, at the same time, the opening and closing of the distributing feed pipes.

The output is regulated by limiting the stroke of the piston to the necessary amount by means of the stop screw R.

Heating the oil.

The oil reservoirs are provided with steam heating coils; on some locomotives a thermostat controls the supply of steam in such a way as to keep the oil at the required temperature. This precaution appears a useful one, given the carelessness with which the American drivers regulate it themselves.

The feed to the various parts.

The oil reaches the various parts to be lubricated through copper or steel piping. The use of saturated steam to convey it from the feed outlet of the pump, a system used on some French lines (Est) is not employed, as far as we are aware, in the United States. The oil is introduced into the steam admission pipe by an injection pipe, extending as far as the centre and at one or two points on the upper surface of the cylinder.

Retaining safety-valve.

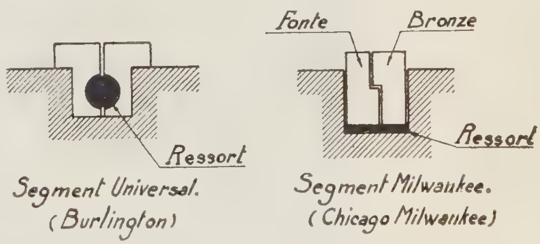
Before the oil reaches the parts concerned it goes through a retaining safety-valve similar to those used in France *(Bourdon)*. The purpose of such valves is to keep the oil feed piping under pressure and prevent it from emptying while the engine is running with regulator closed; in those circumstances any excess of oil reaching the cylinders becomes carbonised and leaves a deposit; in addition during the time the feed piping takes to refill no lubrication is available; the American railways attach great importance to the good working of these valves. A nozzle allows of their setting being verified on the spot by means of a gauge.

Burlington piston rings.

Reference may here be made to some interesting types of piston ring; on the Burlington line the high-speed locomotives, which occasionally replace the diesel trains (Chicago-Denver), have light-weight pistons in aluminium alloy, fitted with two nickel-bronze rings (fig. 4). Each ring is formed of two half rings, in 8 parts, which a circular spring maintains against the cylinder wall. The makers are the Loco Finished Material Co., Atcheson, Kansas. The Burlington is very satisfied with this form of ring, which it appears, can run over 150 000 km. (93 000 miles) without replacement.

Milwaukee piston rings.

The high-speed locomotives on the Chicago-Milwaukee line are fitted with two rings, each formed of two halves, one in bronze, the other in cast iron; each half ring is formed of twelve elements applied against the cylinder wall by a flat section spring around the piston (fig. 5).



Figs. 4 and 5. — Burlington and Milwaukee types of piston rings.

Note. — Fonte = cast iron. — Ressort = spring. Segment = piston ring.

Consumption of cylinder oil.

Statistics supplied by the North Western show that the consumption of cylinder oil was 10 gr. per kilometre (3.55 lb. per 100 miles) in November, a relatively low amount, if the great power of the locomotives is taken into account.

II. — LUBRICATING THE MOTION.

Although cylinder lubrication on the American railways is very much like that used in France, this is not the case with the motion. In France the latter is generally lubricated from oil cups, but grease lubrication is employed in America.

The Americans object to the oil cup arrangement, saying that it lubricates irregularly and is wasteful if the cups are not tight. It must be recollected that the motion parts are almost all made of unlined bronze or steel, and that friction of bronze on steel often adapts itself more readily to grease than oil.

The railways use two qualities of grease, soft grease for the smaller parts — valve gear — similar to the grease used for lubrication on road motor vehicles, and a fibrous form of grease for the heavier parts of the motion. The latter grease is composed of a mixture of soda soap and an ordinary cylinder oil, an example of its composition being :

Cylinder oil, 600° F. flash point	49 % by weight.
Stearic acid	39.25 %
Caustic soda	7 %
Water	4.75 %

The grease is in a container carried, like oil cups, on the rod ends, and is kept in by Tecalemit type nipples, or by simple screw caps which the driver adjusts from time to time.

On those parts where the lubrication must be particularly looked after on account of the loads borne by them, such as the big ends, the lateral greasing is supplemented axially (fig. 6) ; the grease is contained in a hollow space inside the crank pin and reaches the bearing surface through radial channels; it should be pointed out that in the United States the big end is fitted with a pressed on cast iron ring, in which a bronze ring, known as the floating bush, is held by light friction and is pierced with a number of holes.

The hollow spaces in the pins are filled at regular intervals by special gangs by means of Alemite (Tecalemit) equipment, hand or air operated (figs. 7 and 8).

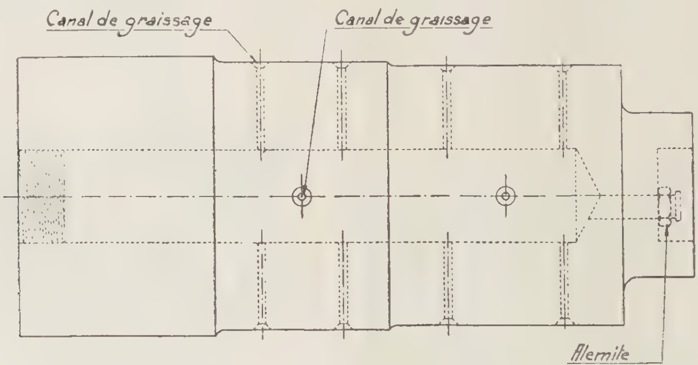


Fig. 6. — Big end crank pin.

Note. — Canal de graissage = oil passage.

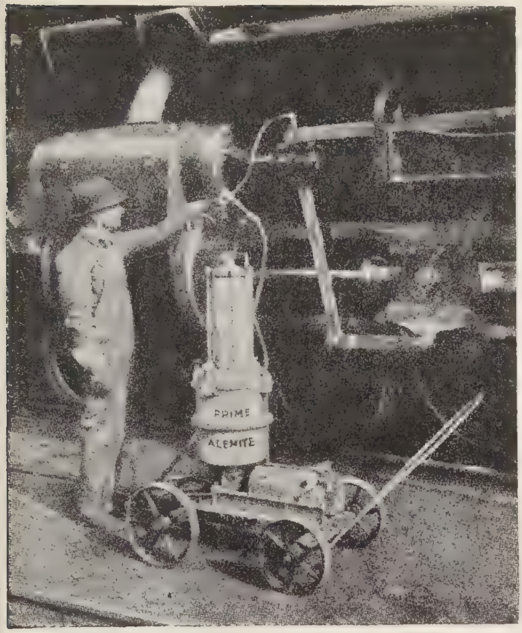


Fig. 7. — Pressure grease lubrication of valve gear.

The American railways express themselves on the whole well satisfied with this method of lubrication. On some recent ultra-high speed locomotives on the Burlington, the motion is provided with Timken roller bearings, which have proved satisfactory, but this expensive arrangement has as yet been little developed. The greater number of the other locomotives, even the high-speed ones, such as the Hiawatha, still have grease lubrication for the motion.

III. — AXLE LUBRICATION.

Grease.

For many years the American railways have lubricated their locomotive axles with hard grease for the driving wheels and packing for the carrying wheels. Packing is also used for the carriage and wagon axles.

The grease is generally the same as that used for the large parts of the motion; it is delivered to the running sheds in cylindrical form, and is pressed into

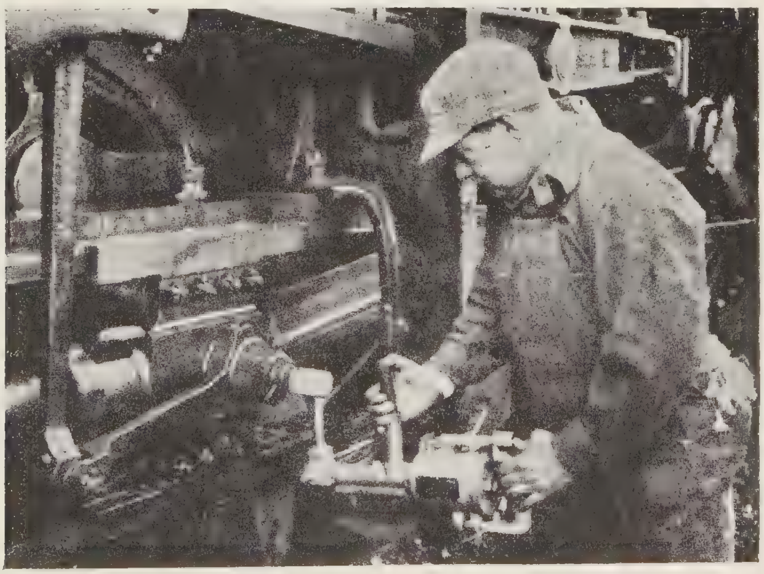


Fig. 8. — Pressure grease lubrication of motion.

suitable cakes by a machine. The cakes are placed in the axle-boxes and kept in contact with the journals by spring power; between the axle and the grease cake there is a perforated plate which serves to regulate the flow.

These cakes weigh 5.5 kgr. (11 lb.) and suffice for varying lengths of runs according to circumstances, the average for the Chicago-Milwaukee high-speed locomotives being 15 000 km. (9 300 miles).

The inspection and renewal of the cakes is easily effected by lowering the interior covers of the axle boxes.

Among the advantages attributed by the American railways to grease lubrication we may mention :

Simple maintenance (water which may get in when running or washing out the boiler, causing no harm);

Automatic improvement in the lubrication should heating occur (as the temperature rises the grease melts); finally, as with the parts of the motion, the driving axles are mounted on unlined bronze bearings, which are not satisfactory with the fluid oils of the usual types. However, it is objected that grease lubrication is slow in acting (difficult starting), that there is a certain degree of irregularity in the consumption of the cakes and that its working lacks reliability, particularly when the springs which keep the cakes pressed against the journals subside.

These disadvantages do not prevent the running sheds from being satisfied with the process; it is, however, being progressively replaced by roller bearing boxes.

Packing.

Packing is still the method of axle lubrication most used in the United States (for wagons and carrying axles on locomotives). It is generally composed of cotton threads (North Western, Santa Fe), but on some railways a mixture of cotton and wool is used (New York Central; 40 % cotton, 60 % wool). In addition it has some horse hair with it, or metallic springs (25 per kgr. or 11 per lb.) to give it elasticity (vegetable fibrous material is used on the goods wagons).

Method of using the packing.

This is well known in France; the packing material is first steeped in warm oil, then left to drain off for twenty four hours; this process terminated, the packing is ready to be put in place. Its oil content should not then exceed 3 lb., of oil to each lb. of dry waste. Some railways make up the packing into pads enclosed in bags, to prevent the threads from being taken up by the journal into the bearings and causing heating.

The maintenance is simple : oil is added from time to time, and by means of a sort of feeler rod, the packing which has a tendency to get squashed up, is loosened.

Twice a year the packing is taken out and renewed, the oil being changed at the same time. Most of the American railways in fact use two qualities of oil, for winter and summer. The packing is renovated in various service depots on the system; after being freed of oil by heating, it is separated in a centrifuge machine, combed and sorted. The reclaimed material is then mixed with fresh packing in varying proportions, according to the use it is intended for.

Some railways (the Pennsylvania, at Harrisburg) completely regenerate the recovered oil, comprising neutralisation with soda and washing with water, but most railways content themselves with a strong centrifugal treatment or simple filtering. The recovered oil is then mixed with new in varying proportions.

The use of packing has the advantage of being simple, but the railways say that the maintenance is rather costly and it is not efficient enough. On the

Chicago and North Western, for example, the number of hot boxes was as high as 3 576 in 1937, or one per every 240 000 wagon-kilometres (150 000 miles), the average delay caused being 19 minutes.

Quality of wagon oils.

Table 2 gives a comparison of the specifications issued by the Association of American Railroads and the French railways.

It will be seen that they are very much alike (1). The use of one oil for winter and another for summer is still often preferred to using the same oil all the year round. According to the Chicago and North Western, the trials of an « all the year » oil were not favourable, owing to the wide differences in the temperature at different seasons. Other lines declare that the change over from one oil to another takes all the year to complete, so that a large number of wagons are running in winter with summer oil and vice versa, which does away with any advantage derived from the use of two qualities.

TABLE 2. — **Wagon oils.**

—		Specification of the *Association of American Railroads.* summer.	winter.	all year.	recovered.	Specification of French Railways.
Flash point, open vessel	° C.	149	149	149	121	150
	° *F.*	*(300)*	*(300)*	*(300)*	*(250)*	*(302)*
Engler viscosity at 100° C. (212° F.), stipulated		1.5	1.1	1.3	Lying between those for winter oil and summer oil.	...
Engler viscosity at 38° C. (100° F.)	desirable	12	7.1	...	...	at 50° C. (122° F.) : 5.9.
	stipulated	19.5	8.1	8.1	...	at 35° C. (95° F.) : 13.5.
Liquefaction	° C.	— 6.5	— 17.5	— 17.5	+ 7	...
	° *F.*	*(+ 20)*	*(0)*	*(0)*	*(45)*	...
Asphalt soluble in chloroform.	%.	0.10	0.10	0.10	Precipitation number, 0.5.	Not soluble in petroleum spirit : 0.3.
Sediment	%.	0.10	0.10	0.10	No deposit on 325 mesh filter.	0.05

(1) The asphalt and sediment contents are measured in the following manner; the oil is kept shaken for two hours at a temperature of 100° C. (212° F.), a 5 grammes sample is diluted with 200 cm³ of light petrol, the precipitate being filtered, dried and weighed, and the asphalt separated from the sediment by being dissolved in chloroform.

The « precipitation number » is obtained by diluting the oil with petrol, centrifuging the mixture in a graduated tube and noting the volume of dark coloured liquid which collects at the bottom.

Consumption of oil.

According to statistics recently drawn up by two eastern railways, the oil consumption varies between 5 and 9 litres per 10 000 wagon-km. (1.9 and 3.2 Br. gall. per 10 000 wagon-miles).

Pad lubrication.

This is as yet little developed in the

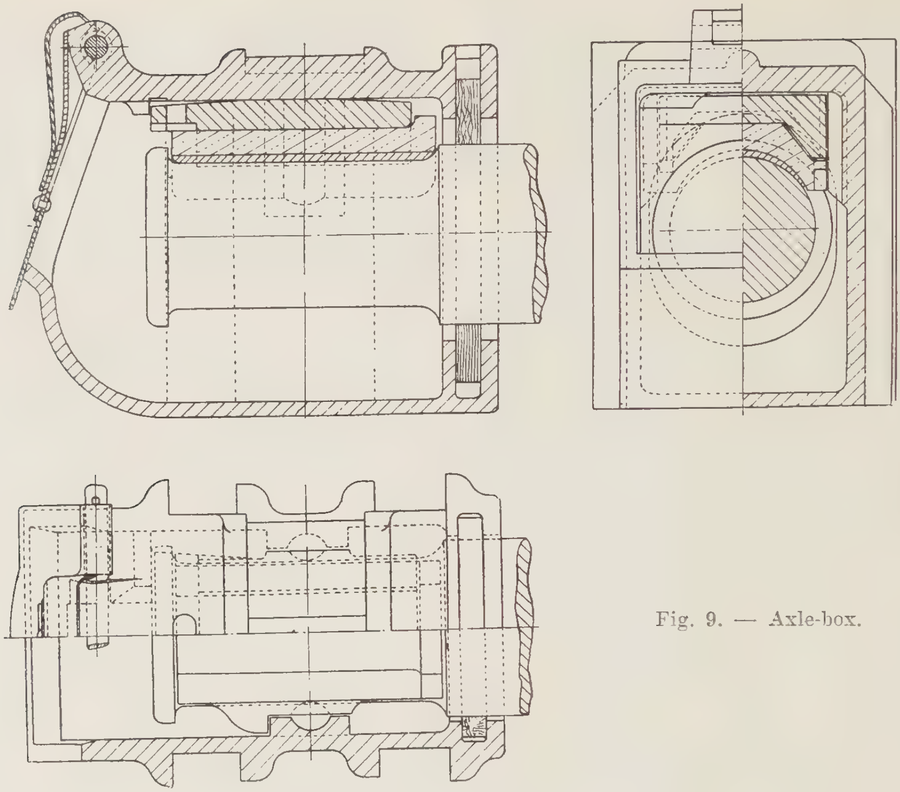


Fig. 9. — Axle-box.

United States. During the last two years, however, the railways have begun to take an interest in it and have tried various types of it with success. The Magnus pad lubricator (fig. 13) may be particularly mentioned; the holder is formed of two crossed U's under the control of coil springs.

Pressure lubrication.

Pressure lubrication of the bearings, by means of a central pump is little used on the American railways, who fear the complication of the fixed and flexible piping which it necessitates. The Santa Fe is an exception; on its steam and its first high-speed diesel locomotives for the Chicago-Los Angeles service *(Super Chief)* the bogie axles are lubricated in the following manner :

The boxes, of the ordinary pattern, are provided with packing. A *Chicago* type multiple pump with six feeds, mounted on each bogie, feeds oil under pressure to the two sides of each axle-box; the lubricator is driven by an electric motor fed from the locomotive lighting dynamo. The railway is very satisfied with this system, which has given only one hot box for 500 000 km. (310 000 miles) travelled. However the new locomotives of the same type are now provided with roller bearings.

The Hennessy apparatus.

In addition to the axle-boxes with

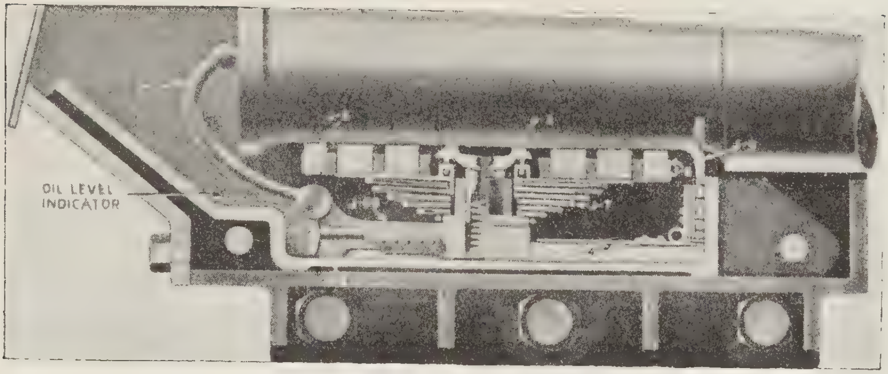


Fig. 10. — Hennessy lubricator for outside journal.

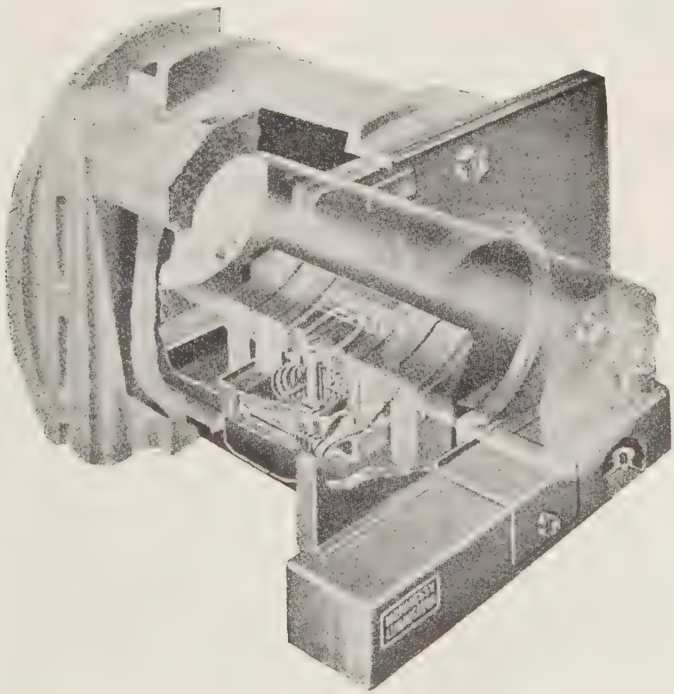


Fig. 11. — Hennessy lubricator for inside journal.

packing or roller bearings, which are in general use, there are certain appliances still little developed, but which are of interest. We may mention, in particular, the *Hennessy* individual pressure lubricators (figs. 10 and 11) used by the Baltimore and Ohio on its new « Emerson » locomotives. This device consists of a pump with a flap valve fitted into the axle-box and actuated by the lateral displacements of the bogie frame with respect to the axle.

These displacements are transmitted by the lever J. 1. to the immersed pump J. 2., which forces oil back to the centre of a felt pad, pressed against the journal by a spring. The appliance is in two parts, so that it can be easily introduced into the axle boxes in service. A thick oil is used [4 to 5 Engler at 100° C. (212° F.)]. Maintenance consists in cleaning the pads and changing the felts once a year. The mechanism will only work if the axle boxes are given a certain amount of lateral play, which, on the American railways, is 6 mm. (1/4"), or 3 mm. (1/8") each side. The feed obtained reaches 5 litres (1.1 Br. gall.) per minute at high speeds.

Bearings.

As has been pointed out above in speaking of piston rings, the question of the nature of the metals used for the rubbing surfaces is connected with the question of lubrication. A few remarks will therefore be made on the manufacture of bearings for locomotives.

For the rod ends the American lines use a so-called « floating » ring or bush, of phosphor bronze of the following composition :

Tin	9 to 11 %
Lead	9 to 11 %
Phosphorous	0.2 to 0.4 %
Zinc	0.5 %
Impurities (maximum) . . .	1 %
Copper	the remainder

This bush is pierced with holes which, on some railways have anti-friction metal inserts. The bearings for locomotive driving wheels are in soft unlined bronze of the following composition *(Association of American Railroads)* :

Tin	4 to 6 %
Lead	23 to 27 %
Zinc	0.75 %
Other impurities (max.). . .	0.75 %
Copper	the remainder

Those for the carrying wheels are in bronze (lined) of the following composition :

Tin	6 to 8 %
Lead	14 to 22 %
Zinc (max.)	1.25 %
Other impurities (max.). . .	0.75 %
Copper	the remainder

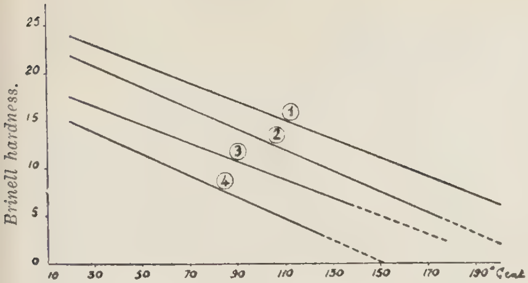
The carriage and wagon bearings, and those of the locomotive bogies are lined with anti-friction metal of the following composition (specification of the *Association of American Railroads)* :

Lead.	85 %
Antimony	10 %
Tin	5 %

The bearings are not hand bedded, but are accurately machined before being put in place. Statistics covering three years on two large eastern railways show the average replacement of bearings to have been 1.2 to 1.5 per 10 000 goods wagon-km. (1.93 to 2.4 per 10 000 wagon-miles), and 0.6 to 0.9 per 10 000 passenger coach-km. (0.96 to 1.45 per 10 000 coach-miles).

Satco metal.

A number of railways (Chicago & North Western, Baltimore & Ohio, New York Central) make successful use of an anti-friction metal called « Satco » made by the Magnus Co., a subsidiary of a



① *Satco.*
② Antifriction metal : tin 88 %; antimony 8 %; copper 4 %.
③ Railway's own antifriction metal : lead 85 %; antimony 10 %; copper 5 %.
④ Antifriction metal : lead 87 %; antimony 13 %.

Fig. 12. — Comparative hardness of different bearing liners.

large lead producing concern (National Lead). This metal is composed of :

Lead.	98 %
Calcium and other ingredients . . .	2 %

Il is applied to the bearings, after they are tinned, by a moulding or centrifugal process.

The manufacturers of « Satco » emphasise the high degree of hardness it retains under heat, and in consequence its resisting properties when a box gets hot. All the railways using it appear very satisfied with its performance.

Oil circulation bearings.

We may also mention an interesting type of « Self cooling » bearing made by the *Magnus* and the *Locomotive Supply* Companies (fig. 13). As is known, the journal when rotating takes with it a large quantity of oil, of which only a very small amount effectively reaches the bearing surfaces. In the « Self cooling » type, grooves are cut in the walls to allow the oil to pass from one side to the other. The circulation of the oil

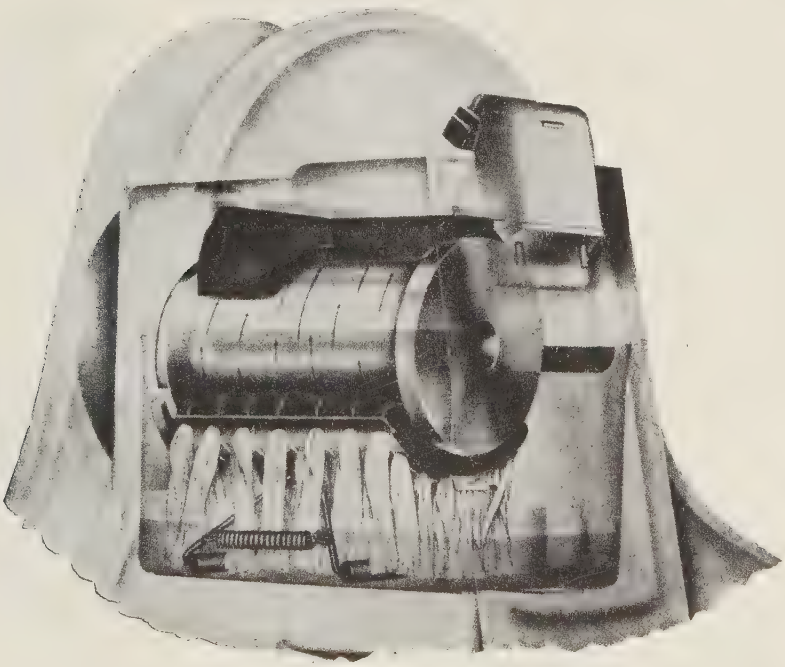


Fig. 13. — Magnus bearing with pad.

helps to cool the metal and effectively counteracts any tendency to heating; trials on the test bench and on the road show that the average temperature was reduced by some 15° C. (27° F.).

In addition a certain amount of oil remains in the grooves and provides lubrication at the moment of starting. This type of bearing is generally associated with the pad already spoken of and appears to meet with a certain amount of favour.

Hot box warning indicator.

We may also mention the indicators to give warning of a hot box, manufactured by the same company, formed of tubes fitted with fume-emitting material and placed in the bearings after being sealed with a lead fuse; at 165° C. (329° F.), where the temperature is becoming dangerous, the lead fuse melts and white, strong smelling smoke is emitted, thus giving the warning. When this occurs, instead of trying to reach the next station, the train can be stopped at once and the bearing be renewed with the aid of a screw jack (1).

Roller bearing boxes.

The use of roller bearings for passenger stock is now old. It has been successively extended to tenders, then locomotive bogie and pony truck axles, and finally, during the last two years, to the driving axles. At present the new locomotives most often have all their axles equipped with such bearings. *(Timken* or *S. K. F.)* (fig. 14); this is the case, for instance, with the latest New York Central engines which have the following characteristics :

— Type 4-6-4;

— Total weight of engine without tender : 165 t. (162.4 Engl. tons);

— Weight on each driving axle : 29 t. (28.5 Engl. tons);

— Weight on each pony truck or bogie axle : 22 t. (21.65 Engl. tons);

— All axles on roller bearings.

The difficulties formerly met with in service with this type of bearing, such as breaking of the cage, cutting of the journals, races getting out of place, and rapid wearing of the roller cones, have been overcome. The average distance covered with carriages is now 1 600 000 km. (1 000 000 miles) for the box itself and 750 000 km. (466 000 miles) for the cones.

In spite of their high price (150 dollars for a tender roller bearing box) the American railways are extending their use. Their chief advantage is not so much the reduction in friction at starting, as simpler maintenance and the elimination of hot boxes, enabling a better

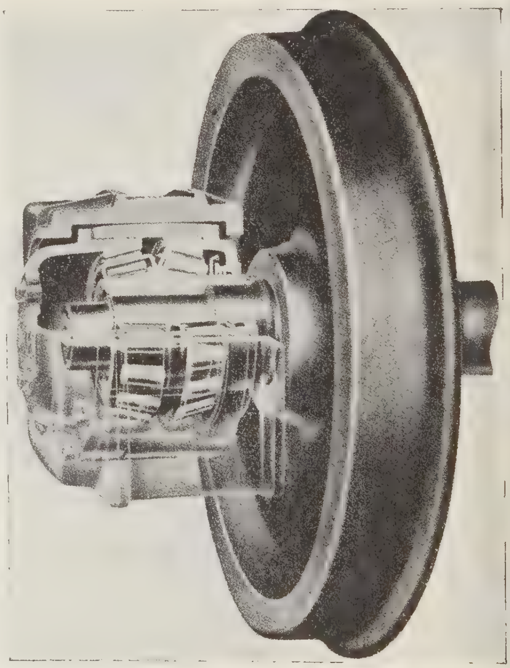


Fig. 14. — Roller bearing axle-box.

(1) This old method is made possible by the arrangement of the axle-boxes; it owes its origin to the long distances separating the stations and running sheds, in the Middle West especially.

utilisation to be made of the locomotives.

Lubrication.

A thick oil is used having the following characteristics :

Density	0.900/950.
Flash point	230° C. (446° F.).
Viscosity (100° C.-212° F.)	3 to 4.5. Engler.
Colour	green.
Freezing point	4° C. (39.2° F.).

In winter an oil having a freezing point of —10° C. (14° F.) is insisted upon. Some railways use the same oil as that employed for the ordinary axle-boxes.

Every month in the case of carriages and at every wash-out in the case of locomotives, the oil level is checked with a gauge and brought to the required height as necessary. The boxes are cleaned and refilled with oil at least once a year.

The oil consumption, formerly somewhat high, has been greatly cut down by means of an oil return deflection baffle (see diagram) which also has the advantage of preventing dust and water getting in, essential for keeping the bearing in good condition. A box consumes about 1 litre of oil per 60 000 km. (1 pint to cover 21 000 miles approx.).

Tender axle boxes.

We may also mention an old arrangement in use on tenders, which appears much favoured by its users.

The two wheels of an axle are mounted on roller bearings, the axle being of ordinary type with journals carried in ordinary boxes filled tight with packing. In normal running the axle does not rotate; but should a roller bearing get jammed, the axle commences to revolve without interfering with the running of the train.

IV. — LUBRICATION OF LOCOMOTIVE DIESELS.

The diesel-electric locomotives generally comprise an electric generator driven by a diesel engine and furnishing current to motors mounted on the bogies [1].

This kind of locomotive used for some time now for shunting operations at stations, has been remarkably developed in the last three years for working light fast trains over long distances.

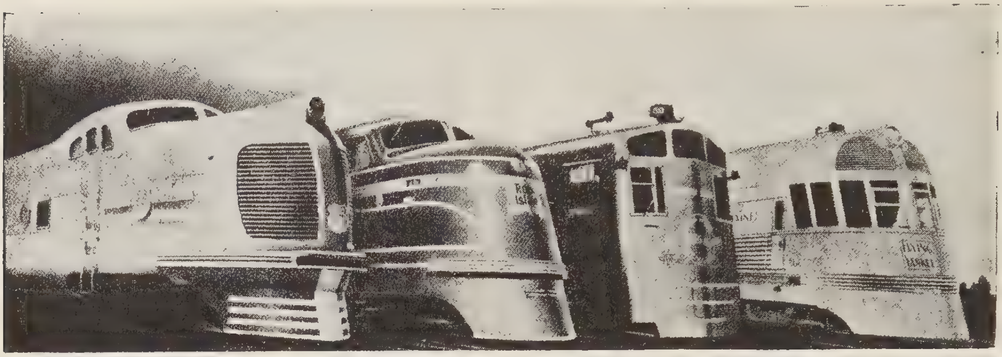
The trains are of varying length and power, from 3 carriages and 1 200 H.P. (Rock Island) to 17 carriages and 5 400 H.P. (Chicago & North Western).

The following are examples of runs made; three railways make the Chicago-San Francisco or Los Angeles run, about 3 700 km. (2 300 miles), in 39 h. 45 m. at an average speed of 93 km. (58 miles) per hour. The *Burlington Zephyr,* already mentioned, makes the run daily from Chicago to Denver, about 1 633 km. (1 015 miles) in 15 h. 15 m. on the outward run, at an average speed of 109 km. (67.7 miles) per hour, or 106 km. (65.9 miles) per hour on the return trip; over one 200-km. (125 miles) section of the route its average speed is 127 km. (79 miles) per hour. With only 6 carriages it made the same run, for trial purposes, at 137 km. (85 miles) per hour.

Description of the Denver Zephyr.

This train, for example, comprises 10 carriages and a twin-unit locomotive; the first unit is 17 m. (55' 9") long, weighs 110 t. (108 Engl. tons) and develops 1 800 H.P., from two 900-H.P. engines; the second unit is 16 m. (52' 6") long, weighs 103 t. (101.3 Engl. tons), and has one 1 200-H.P. engine. The complete train weighs 830 t. (817 Engl.

(1) The photographs on pages 942 and 943 are general views of the most widely used locomotives of this type.



tons) and accomodates 309 passengers, 93 in sleeping berths. Completely covered in *Budd* stainless metal, it has a most striking appearance.

The Electromotive Corporation's engine.

The locomotives, of various powers, have almost all come from the Electromotive Co., a subsidiary of General Motors. Seeing that the question of lubrication is closely connected with the general characteristics of the engine, we think it of some use to give a short description of it.

The *Electromotive Co.* employs three types of *Winton* engine (fig. 15), and

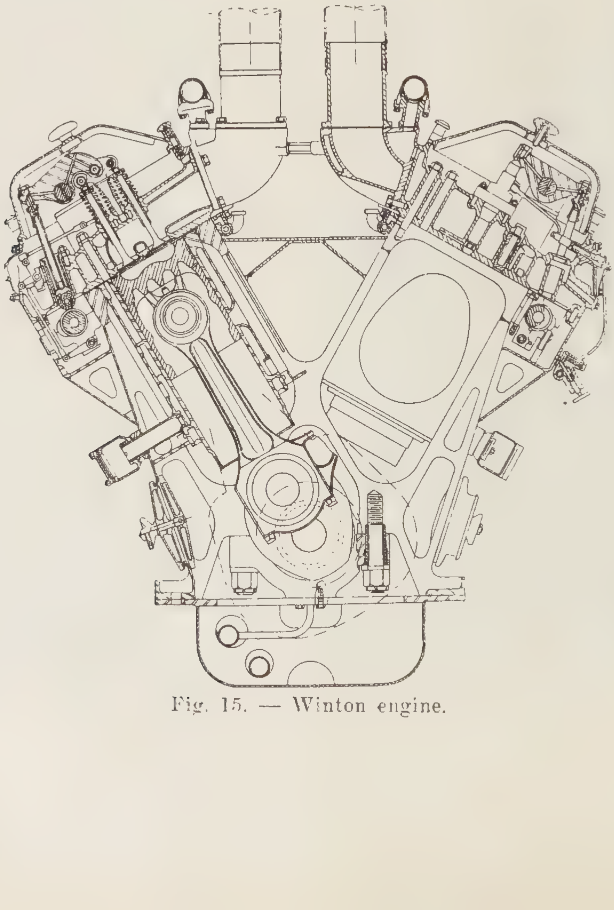
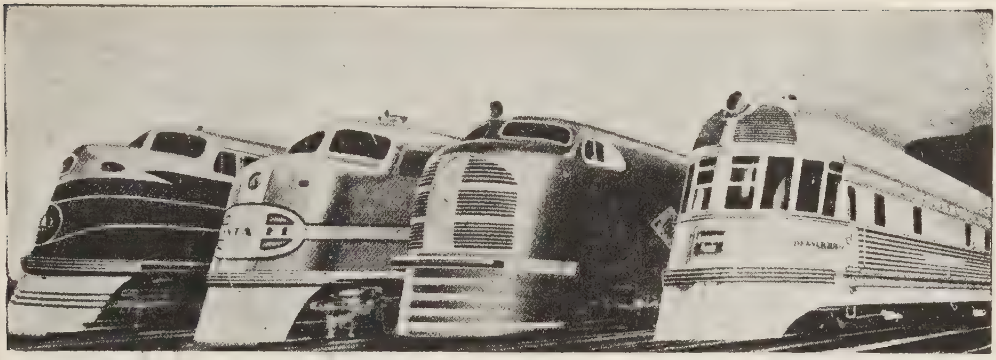


Fig. 15. — Winton engine.



builds a whole series of locomotives of various powers by grouping engines together. The three types are :

— the 8-cylinder, in line, of 600 H.P.;

— the 12-cylinder, V-type, of 900 H.P. (the type most used);

— the 16-cylinder, V-type, of 1 200 H.P.

Each engine is of the two-stroke type, making 750 revolutions per minute, and weighs on the average 10 kgr. (22 lb.) per H.P., rather a high figure for a two-stroke engine.

The cylinders are kept in place in the main framing, with their water jackets, by the cylinder heads and can be changed in a few minutes. The pistons are of aluminium and have five cast iron rings; the connecting rods on the engines of the V-type are coupled to act in pairs on the same crank pin. The inside bearings of the crank shaft itself are held by screw-adjusted wedges and can be changed on the spot without lifting the motor.

The bearings generally have « Satco » liners (98 % lead alloy); the railways declare themselves satisfied with this material and seem to prefer it to the copper alloys previously used. Compressed air circulates through passages formed in the frame and enters the cylinders through lateral ports. The four exhaust valves, on the V-type engines, are arranged in the cylinder cover, around the central injector.

Each cylinder is fitted with its own injection pump. Using a well known design, the pump piston is cut bevel shaped and the amount of the feed is regulated by pivoting it. The injector pressure : 100 kgr. (1 482 lb./sq. in.) is placed under, and is part of, the pump. A central pump maintains an abundant circulation of fuel oil in the injectors, and cools them at the same time.

Movement is transmitted to the pumps by a cam shaft which also controls the lifting of the exhaust valve.

The oil circuit is on well known lines (fig. 16); a geared pump draws oil from the gear case and forces 90 % of it into

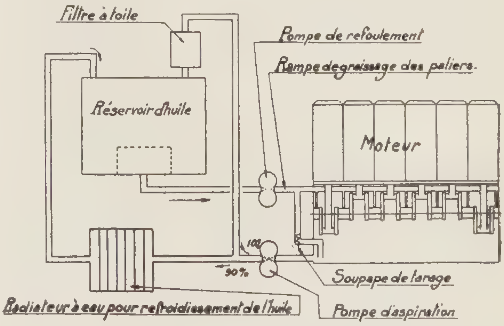


Fig. 16. — Winton engine lubrication circuit.

Note. — Filtre à toile = cloth filter. — Réservoir d'huile = oil reservoir. — Pompe de refoulement = delivery pump. — Moteur = engine. — Rampe... des paliers = feed slope for lubricating the bearings. — Soupape de tarage = feed adjusting valve. — Pompe d'aspiration = suction pump. — Radiateur... l'huile = water radiator for cooling the oil.

a water-cooled radiator and the rest into a cloth filter. Such filters appear to be much more efficacious than those of the comb or felt type, usually fitted on the French engines. The *Nugent* filter (one of the most widely used) is composed of a spirally wound bag on a metal frame (fig. 17). The bag is cleaned in petrol about every 5 000 km. (3 100 miles).

The oil, on leaving the filter and radiator, passes into a reservoir of 400 l. (88 Br. gall.) (900-H.P. engine), from which it is taken by a second pump, similar to the first, and forced into the crank shaft. It passes into the connecting rods through baths arranged laterally; through the channel formed in the rod it reaches the centre of the piston and cools the piston top by spray action. 400 l. (88 Br. gall.) of oil are required for a 900-H.P. engine.

The amount in circulation is particularly heavy, reaching 350 l. (77 Br. gall.) per minute, with a pressure of 1 500 kgr. (3 300 lb.). The make-up consumption is about 4 to 5 l. (0.9 to 1.1 Br. gall.) on the average for 1 000 H.P.-hours.

Checking the condition of the oil.

The oil is examined periodically to test its condition, and changed either after a given mileage or more often when its characteristics exceed certain limits.

The average distance is about 25 000 km. (15 500 miles), i.e. greater than that obtained in France (4 000 to 6 000 km. = 2 500 to 3 700 miles), but the volume of oil in circulation is much greater.

The checking of the oil for viscosity and carbon content is done either at the running shed (Santa Fe) or in the laboratory (New Haven).

This method has first of all the advantage of prolonging the life of the oil. It also gives a check on the condition of the engine and quickly reveals any defect in the working : rapid dilution, for instance, is an indication of the splutter-

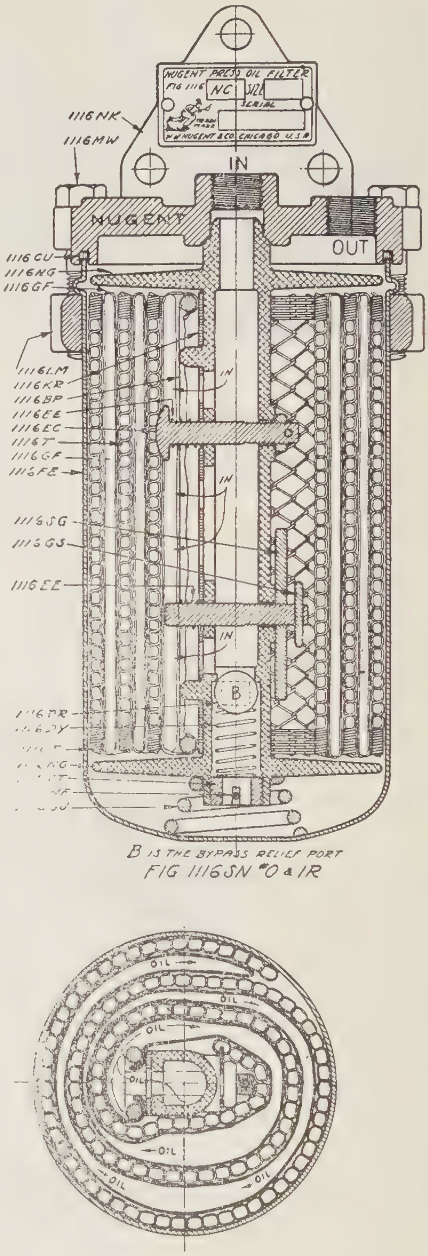


Fig. 17. — Nugent filter.

ing of the injectors or want of tightness in the piston rings. Finally this control gives great reliability.

Maintenance of mechanical parts.

The maintenance of the mechanical parts of the engine is carried out in a rather particular way: on arrival the engines are handed over to a gang of specially trained men who during the few hours the locomotive is stationary carry out any necessary repairs. Thus replacement of parts and cleaning are done at each such waiting period; decarbonising is done, for example, piston by piston every 100 000 km. (62 000 miles) without interrupting the work of the locomotives. This method of maintenance is only possible because all the parts of the engine, except the crank shaft, can be changed on the spot. This allows the heavy overhauls to be spaced at considerable intervals, after running 700 000 km. (435 000 miles) against 150 000 km. (93 000 miles) in France.

TABLE 3. — **Operating costs on the Chicago & North Western for November 1937.**

	City of Denver (diesel).	The « 100 » (steam).
Miles run	29 280	26 816
Expenses (dollars) :		
Wages	8 986	7 667
Coal or fuel oil	2 826	6 827
Lubricants and water	703	531
Other supplies	1 370	1 897
Repairs	15 433	8 804
Total	29 318	25 726
Per mile :		
Wages	307	28
Coal or fuel oil	096	25
Lubricants and water	024	02
Other supplies	046	07
Repairs	527	33
	1.00	0.95

Operating costs.

Table 3 shows the operating costs as given by the Chicago & North Western, in November 1937, for a diesel train and a steam train working similar services. It is to be noted that with the diesel the extra cost for repairs has to be set against the saving in fuel which fails to compensate for it.

Lubricants.

The American railways do not usually buy their lubricants against specifications. Attempts to do so, made by certain railways (New York, New Haven) have not been followed up; most of them simply request the suppliers to study the lubrication problem and determine on a suitable kind of oil.

The viscosity of the oils in use varies from 1.5 to 2.25 at 100° C. (212° F.). The following are the characteristics of the oil used by the New York, New Haven for its Westinghouse engines :

Flash point	194° C. (380° F.).
Viscosity at 38° C (100° F.)	21, Engler.
Viscosity at 100° C. (212° F.)	1.6, Engler.
Liquefaction	— 30° (— 22° F.).
Carbon test	0.10.
Ash content	0.003.

Following certain failures caused by the rapid gumming of the oil, some manufacturers have been led to investigate new kinds. It is interesting to see what practical experiments have been made in the attempt to do this. How to make a trial of an oil is a question which has often to be solved.

In the laboratory of a large oil refinery in an Eastern State each type of oil is tried on a *Caterpillar* type single-cylinder diesel engine. The piston ring wear is compared, and also the appearance of the pistons, after a certain number of hours running (60), without tak-

ing account of the varying characteristics of the oil.

The oil refineries say that the results of such experiments correspond very well with those obtained in service. This is not the case with the simpler laboratory experiments, such as the *Sligh* or *Indiana* oxidation tests. As is known, these consist in heating the oil in the presence of air or oxygen. It is practically admitted that these tests are incapable of forming a guide to conditions in service, unless it is a question of samples all from the same source.

Fuels.

Table 4 gives a few fuel oil specifications used by the railways. The Electromotive Co. requires a minimum cetane number of 50.

As a general rule the cetane number is not measured by the railways' own laboratories; on the New York, New Haven only the aniline point is measured.

SUMMARY.

The impression gained from this rapid survey is that the American railways attach great importance to getting efficient lubrication, simplicity of maintenance and strength of equipment used being given first attention. As to the quality of the oils, the investigations of the refineries have chiefly been directed to producing oils for diesel engines, and interesting results have been obtained.

TABLE 4. — **Oil specifications for high-speed diesels.**

—	*New York New Haven.*	*Chicago and North Western.*	*Electro-motive.*	*Specifications French Nat. Rys. Co.*
Density	...	0.843 to 0.864	...	...
Flash point	66 PM	90 to 93 (open vessel)	66 PM	81—110 Luchaire.
Sulphur, %	1	0.5	0.5	0.5
Diesel or cetane index .	D. I. 45	...	50	50
Liquefaction.	Summer + 5° C. *(41° F.)* Winter — 15° C. *(— 13° F.)*	...	— 32° C. *(— 26° F.)*	— 15° C. *(+ 5° F.)*
Viscosity at 38° C. *(100° F.)*	35/45 S. (1.2 to 1.4 E.)	35/40 S. (1.2 to 1.3 E.)	35/70 S.	Below 1.6 E. at 20° C. *(68° F.)*
Water and sediment, %	...	...	0.1	...

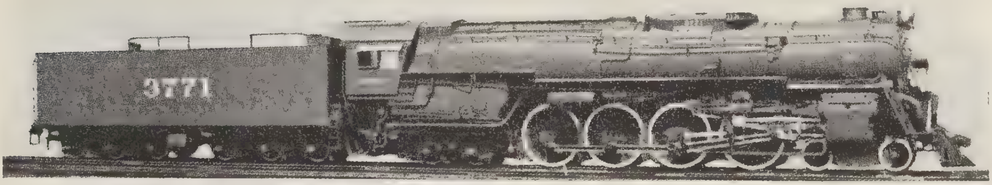
Regeneration of the oil.

Used oil is not regenerated on the New York, New Haven or on the Pennsylvania. On the Chicago and North Western it is reused, after being centrifugalized and filtered, in the locomotive axle-boxes.

[621. 132.3 (.73) & 621. 132.5 (.73)]

New 4-8-4 passenger and 2-10-4 freight locomotives for the Atchison, Topeka and Santa Fe Railroad.

(*Railway Age.*)



Santa Fe passenger locomotive for use over heavy mountain grades — Built by Baldwin.

During 1938 the Atchison, Topeka and Santa Fe took delivery from the Baldwin Locomotive Works of eleven 4-8-4 type passenger locomotives and ten 2-10-4 type freight locomotives. These 21 locomotives are in addition to six 4-6-4 type units (*) delivered early this year. These designs are of special interest because of their high capacity and include many parts which are interchangeable.

The eleven 4-8-4 type locomotives operate between La Junta, Colo., and Los Angeles, Calif., 1 237 miles, in fast passenger service and averaged during August and September 17 250 miles per month per locomotive. Five of the 2-10-4 type locomotives are coal-fired and are used in fast freight service between Clovis, N. M., and Belen. The other five 2-10-4 type locomotives, oil-fired, are used in fast freight service between San Bernardino, Calif., and Winslow, Ariz.

The principal characteristics of the three types are shown in the accompanying table. This article describes the the 4-8-4 and 2-10-4 types only.

(*) Described in the *Railway Age* for March 12, 1938, page 450.

Passenger locomotives.

This group of 11 locomotives was built for service in the mountain country west of La Junta, Colo., where grades of 3 1/2 per cent are encountered. They have a total tractive force of 66 000 lb., weight 286 890 lb. on drivers, and have water and oil capacities of 20 000 and 7 000 gall., respectively.

The boilers.

The shell-course sheets on all 11 boilers are nickel steel. In 10 of the boilers the inside firebox sheets are of carbon steel; in the other they are nickel steel.

The first course is 88 1/4 in. inside diameter and the third course is 100 1/16 in. inside diameter. The second course is conical. The plate is 7/8 in. thick in the first course and 31/32 in. in the second and third courses. The front tube sheet is 5/8 in. and the back tube sheet 9/16 in. thick. The combustion chamber, crown and side sheets and back firebox sheets are 13/32 in. thick. The thickness of the roof sheet is 29/32 in.; the side sheets, 7/16 in.; the outside throat sheet, 15/16 in., and the inside throat sheet and the back head, 1/2 in.

The fireboxes are exceptionnally large,

Oil-burning fast freight locomotive for service on the Atchison, Topeka & Santa Fe Coast Lines. Built by Baldwin.

being 108 in. wide inside and 144 in. long. The crown and sides are in three pieces with a welded longitudinal seam approximately 25 in. above the mud ring. The combustion chamber is 64 in. long. The back door sheet and the side water legs are vertical for distances of 12 in. and 15 in., respectively, in order to simplify the application of the fire-brick lining above the draft pan. Two Thermic syphons are used in the fire-box and one in the combustion chamber. The application of flexible stays is extensive, over 1 700 being used in the firebox and combustion chamber. Flannery crown stays are used with URW sleeves with the exception of the bolts through the flanges of the syphons. Flannery flexible stays with UW sleeves are used on the throat-sheet and combustion chamber. Flexible bolts with UW sleeves are also used in the firebox breaking zones.

Welding has been utilized in numerous locations on these boilers. The longitudinal seams in the wrapper, crown to side sheets, and in the combustion chamber are welded. The mud-ring corners are welded for a distance of 17 in. at the front and 16 1/2 in. at the back. The water-gage and column bosses, and combustion-chamber diaphragm plate are secured by welding. The tubes and flues are welded to the back tube sheet.

The boilers are equipped with the Elesco Type E superheater with American multiple throttle. The feed-water heater is a Worthington 6Sa mounted in front of the stack. There is also one injector : a 12 000-gall. Hancock for one boiler and a 13 500-gall. Chicago for ten

Comparison of principal characteristics of new Santa Fe passenger and freight power.

Type	4-6-4	4-8-4	2-10-4
Service	Passenger	Passenger	Freight
Weight on drivers, lb.	213 400	286 890	371 680
Total engine weight, in working order, lb.	412 380	499 600	545 260
Weight of tender, in working order, lb.	396 340	396 340	359 900
Cylinders, diameter and stroke, in.	23 1/2 × 29 1/2	28 × 32	30 × 34
Driving wheels, diam. outside tires, in.	84	80	74
Wheel base, total, ft. and in.	88—8	98—2 1/2	(5*) 98—7 3/4 (5) 100—3 3/4
Boiler pressure, lb.	300	300	310
Grate area, sq. ft.	98.5	108	121.5
Evaporative heating surface, sq. ft.	4 770	5 403	6 075
Superheating surface, sq. ft.	2 080	2 366	2 675
Rated tractive force, lb.	49 300	66 000	93 000
Tender water capacity, gall.	20 000	20 000	20 000
Fuel capacity, gall.	7 000	7 000	(5) 7 000
Coal, tons	...	...	(5*) 23

(*) Coal-burning locomotives.

The air compressor and feedwater pump of the passenger locomotives are located in front of and below the smokebox.

boilers. Other boiler equipment consists of the Signal Foam-Meter with two automatic electro-magnetic 1-in. blow-off cocks, Crane 2-in. manually operated blow-off cocks, and Coale 3-in. safety valves.

These locomotives are equipped with a Booth burner for the use of oil as fuel but are so designed that they can be changed over to burn coal.

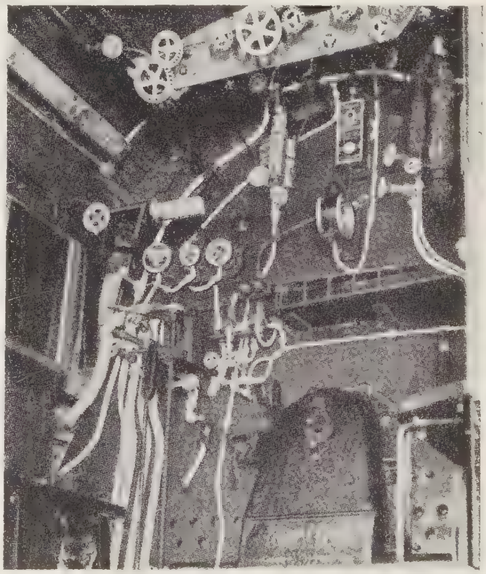
Engine bed and running gear.

A one-piece cast-steel bed, furnished by the General Steel Castings Corporation forms the foundation of these locomotives. Cast integral with the bed are the cylinders and back cylinder heads, and brackets and finish pads for air pump, feedwater pump, waist sheet, guides, valve gear and brake cylinders, as well as supports for a stoker conveyor and for grate-shaker cylinders. These latter are part of the provision for possible conversion to coal as fuel.

The driving wheels are 80 in. in diameter over the tires and have Baldwin disc-type cast-steel centers. All driving journals run in Timken roller bearings with 12 1/2-in. journals on the front, intermediate and back axles and 14 1/4-in. on the No. 2, or main axle. The front drivers are equipped with the Franklin lateral motion device.

The front trucks on these locomotives are of the Batz four-wheel design with the General Steel Castings constant resistance device, 37-in. wheels, inside journals 7 1/2 in. in diameter, and Timken roller bearings. These trucks and the Delta four-wheel trailer trucks are interchangeable with the trucks used on the recently built 4-6-4 type passenger power. In the article describing these locomotives, there appeared a description of the Batz trucks. The trailer trucks have 40-in. wheels, front and back, with 8-in. journals and Timken bearings.

The piston rods and crank pins are



Left side of the back head of one of the oil-burning locomotives.

Right side of the cab in an oil-burning locomotive.

Standard carbon-steel forgings, quenched and tempered, except that the crank pins on the main and No. 3 wheels are heat-treated nickel-chrome steel. The piston head and cylinder packing rings were furnished by the Locomotive Finished Materials Company. T-Z packing is used on the piston rods and valve stems. Laird guides, standard on the Santa Fe system, are used, with high-tensile, cast-steel crossheads made by the Standard Steel Works. The main and side rods are heat-treated chrome-nickel-molybdenum steel. The Tandem main rods are connected to the second and third drivers.

The valve motion is of the Walschaerts type with 60 per cent maximum cut-off which drives 15-in. piston valves with a maximum travel of 7 9/16 in. in forward motion and 7 5/16 in. in backward motion. The valve gear is controlled by a Baldwin type C power reverse gear having a stroke of 24 in.

Lubrication and equipment details.

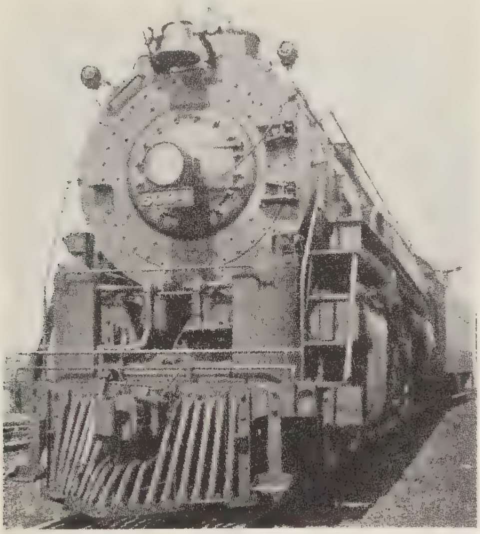
On each locomotive are three force-feed lubricators, one three-feed and one nine-feed on the right side and one four-feed on the left side. On ten of the locomotives both the three- and the four-feed lubricators are Chicago 40-pint, while on the eleventh locomotive they are Nathan 36-pint. All the 9-feed lubricators are Nathan 36-pint. These lubricators feed oil to all driving-box and engine-truck-box pedestal faces, to the two main guides, to the cylinders and piston valves and to the hot-water pump.

Other equipment on these locomotives consists of Westinghouse No. 8 ET brakes with one 8 1/2-in. cross-compound compressor; Viloco sanders and operating valves, 14-in. Pyle-National headlights with Pile-National generators on ten locomotives and the Sunbeam headlight generator on one locomotive; Weston speed recorders; Vapor steam-heat equipment and Ashton steam, steam-heat and air gages.

The coupler at the front of the engine is a National Type E and a Franklin E-2 radial buffer is used between the engine and the tender.

The tenders.

The tenders are of the rectangular type with General Steel Castings Corporation's one-piece cast-steel frames and six-wheel Pullman type tender trucks furnished by the General Steel Castings Corporation. The oil tanks are built as an integral part of the water tanks and have capacities of 7 000 gall. of oil and 20 000 gall. of water, respectively. The tender trucks have Timken bearings, Standard Steel Works wheels and axles and Unit-cylinder clasp brakes with two 12-in. by 10-in. cylinders on each truck. The tender coupler is a National Type E with National yoke and draft gear. Vapor steam heat connectors are used at the rear ends of the tenders.



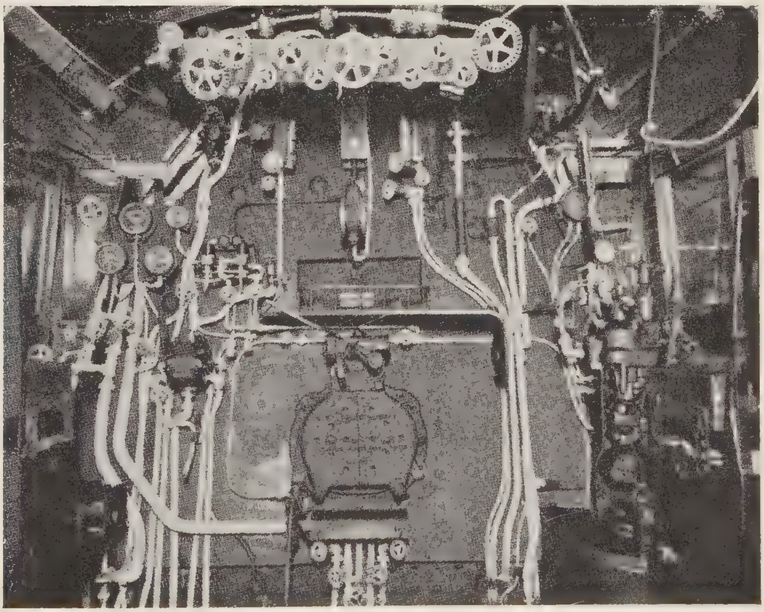
Front end of one of the Santa Fe coal-burning fast-freight locomotives.

The locomotive and tender may be turned on a 100-ft. turntable.

The freight locomotives.

The 2-10-4 type locomotives are a development of the Santa Fe locomotive No. 5000 which was built by Baldwin in 1930. No. 5 000 had 69-in. wheels and developed 93 000 lb. tractive force, whereas the present group of 11 locomotives have 74-in. drivers which, with the 310-lb. steam pressure, produce the same tractive force without any increase in cylinder dimensions. The boiler diameter at the front course is two inches larger than the 5000 class, the grate area is the same and the heating surface slightly less due to a reduction in the number of 2 1/4-in. tubes. The outside diameter of the rear boiler course, in both classes, is 104 in.

The boilers of these locomotives are built in three courses, of which the middle course is conical. They are de-



Back-head arrangement of one of the coal-burning locomotives.

signed for a working pressure of 310 lb. The barrel and firebox plates were furnished by the Lukens Steel Company, nickel steel being used in the barrel courses, liners, firebox wrapper sheets and back heads. Acid carbon steel is used in the combustion-chamber, crown and sides, and throat and door sheets of the firebox, as well as in both tube sheets. The design of the boilers for both the oil- and the coal-burning locomotives is essentially the same; the oil burners are built with a view to conversion to coal if desired.

The outside diameter of the first course is 94 in. and the third course is 104 in. The combustion chamber is 72 in. long. Except for the use of carbon-steel rivets in the backhead, the rivets used in the construction of the boiler shell are nickel steel. Steel rivets are used in the firebox on one boiler only.

The thickness of the plates is as follows : First course, 7/8 in.; second and third courses, 31/32 in.; wrapper sheet, 29/32 in. on top and 7/16 in. at the sides; throat sheet, 15/16 in.; back head and inside throat sheet, 1/2 in.; firebox crown and side sheets, door and combustion chamber sheets, 13/32 in.; front and back tube sheets, 9/16 in.

The firebox is 108 in. wide and 162 in. long, with a grate area of 121.5 sq. ft. Three Thermic Syphons are included, two in the firebox and one on the center of the combustion chamber. The Syphons are welded into the firebox sheets. The coal-burning locomotives have Security brick arches with two 3 1/2-in. arch tubes and the oil burners have the staybolts so spaced that the arch tubes may be installed in event of conversion to coal. Booth 3 1/2-in. oil burners are used on the oil-burning locomotives while the other five have Franklin firedoors and grate shakers and Standard Modified Type B stokers. Cast-steel ash and draft pans are used.

On the fireboxes and combustion chambers are extensive applications of Flannery staybolts. Flexible stays with UW sleeves are used in the breaking zones of the firebox, in the combustion chamber and on the back head. The radial crown stays have URW sleeves and KN round nuts except through the syphon flanges. All flexible and expansion stays are hollow bolts for electrical testing.

All 10 locomotives have Elesco Type E superheaters with American multiple throttles. A Worthington 6SA feedwater heater is applied on all 10 locomotives. The heater proper is located in front of

Comparaison of characteristics of large 2-10-4 type locomotives.

Railroad	A.T. & S.F.	A.T. & S.F.	B. & L.E.	C. & O.	C.B. & Q.
Builder	Baldwin	Baldwin	Alco	Lima	Baldwin
Road No.	5001-10	5000	621-30	3000-39	6010-27
Date built	1938	1930	1937	1930	1927-29
Weight on drivers, in working order, lb.	371 680	349 910	369 100	373 000	355 510
Total engine weight, in working order, lb.	545 260	502 260	520 000	566 000	511 710
Weight of tender, in working order, lb.	359 900	377 840	377 200	415 000	385 690
Cylinders, diameter and stroke, in.	30 × 34	30 × 34	31 × 32	29 × 34	31 × 32
Driving wheels, diam., in.	74	69	64	69	64
Steam pressure, lb.	310	300	250	260	250
Fuel	(5) Coal (5) Oil	Coal	Soft coal	Soft coal	Soft coal
Grate area, sq. ft.	121.5	121.5	106.6	121.7	106.5
Firebox heating surface, total, sq. ft.	632	598	562	645	449
Evaporative heating surface, sq. ft.	6 075	6 114	5 900	6 635	5 904
Superheating surface, sq. ft.	2 675	2 741	2 396	3 030	2 487
Tractive force, engine, lb.	93 000	93 000	97 300	91 584	90 000
Tractive force, booster, lb.	...	...	13 100	15 000	...

General dimensions and weights of the A. T. & S. F. 4-8-4 and 2-10-4 type locomotives.

	4-8-4	2-10-4
Railroad	A. T. & S. F.	A. T. & S. F.
Builder	Baldwin	Baldwin
Road numbers	3765—3775	5001—5010
Date built	1938	June, 1938
Service	Pass.	Frt.
Rated tractive force, engine, lb.	66 000	93 000
Weights in working order, lb. :		
On drivers	286 890	(5*) 371 680 (5) 371 990
On front truck	90 480	(5*) 49 920 (5) 51 120
On trailing truck	122 230	(5*) 123 660 (5) 115 410
Total engine.	499 600	(5*) 545 260 (5) 538 520
Tender	396 340	(5*) 359 900 (5) 393 200
Wheel bases, ft. and in. :		
Driving	21— 3	26—2
Engine, total	48—10	50—2
Engine and tender, total	98— 2 1/2	(5*) 98—7 3/4 (5) 100—3 3/4
Driving wheels, diameter outside tires, in.	80	74
Cylinders, number, diameter and stroke, in.	2—28 × 32	2—30 × 34
Valve gear, type	Walschaerts	Walschaerts
Valves, piston type, size, in.	15	15
Maximum travel, in. :		
Forward motion	7 9/16	7 5/16
Backward motion	7 5/16	6 15/16
Boiler :		
Steam pressure, lb.	300	310
Diameter, first ring, inside, in.	88 1/4	92 1/4
Firebox length, in.	144	162
Firebox, width, in.	108	108
Combustion chamber length, in.	64	72
Arch tubes, number and diam., in.	...	(5*) 2—3 1/2
Thermic syphons, number	3	3
Tubes, number and diameter, in.	52—2 1/4	56—2 1/4
Flues, number and diameter, in.	220—3 1/2	249—3 1/2
Length over tube sheets, ft. and in.	21—0	21—0
Fuel	Oil	(5) Oil (5*) Coal
Grate area, sq. ft.	108.0	121.5
Heating surfaces, sq. ft. :		
Firebox and comb. chamber	427	464
Arch tubes	...	(5†) 22
Syphons	125	146
Firebox, total	552	632
Tubes and flues	4 851	5 443
Evaporative, total.	5 403	6 075
Superheater	2 366	2 675
Comb. evap. and superheat.	7 769	8 750
Tender :		
Style	Rectangular	Rectangular
Water capacity, gall.	20 000	20 000
Fuel capacity, gall.	7 000	(5) 7 000
Coal capacity, tons	...	(5*) 23
Trucks.	6-wheel	6-wheel

(*) Coal-burning locomotives.
(†) Heating surface of two 3 1/2 in. arch tubes on coal-burning locomotives.

the stack; the coldwater pump, on the left side at the rear and the hotwater pump, on the smokebox under the left running board. The injector is a Chicago non-lifting, having a capacity of 13 500 gall. per hour. The safety valves are the Coale 3-in. The boilers are equipped with the Signal Foam-Meter with 1-in. automatic blow-off valves on the right and left sides, piped through a muffler on top of the boiler to the ground. Three Crane blow-off cocks are located in the firebox, one each on the right and the left sides and one in the throat sheet. The boilers are equipped with Huron washout plugs.

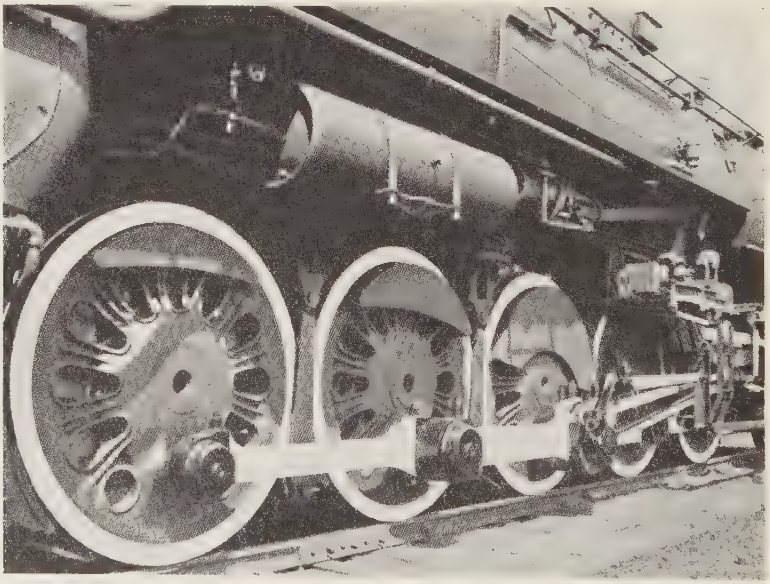
Machinery details.

The cast steel beds under these locomotives were produced by the General Steel Castings Company and are said to be the largest beds yet in service. The overall length of the bed is 60 ft. 8 1/2 in. and the shipping weight, with the pedestal binders in place, is 84 520 lb. The cylinders and back cylinder heads, the air compressor brackets, and the deck-plate and valve-motion supports are cast integral on all 10 beds. Stoker conveyor and grate-shaker cylinder supports are cast as a part of the oil-burner beds as well as of those for the coal-burning locomotives, to provide for conversion to coal as fuel.

The front engine trucks are the two-wheel outside-bearing type furnished by the General Steel Castings Company. They are designed with a one-piece cast-steel frame with provision for 7 3/8 in. swing each side of the center line. The engine-truck wheels are 37 in. in diameter and the axles have 8-in. by 14-in. journals with plain bearings.

The four-wheel trailing trucks are the Delta design with centering device. Both axles have 9-in. by 14-in. journals and 40-in. wheels.

The cylinders are 30 in. bore by 34 in. stroke. Cast-iron cylinder and valve-chamber bushings, heat-treated alloy pis-



Details of the running gear of one of the 2-10-4 type locomotives.

The engine bed casting for the Santa Fe 2-10-4 type locomotives.

ton heads, phosphor-bronze cylinder and valve packing rings, carbon-steel piston rods, cast-steel Laird-type cross-heads with carbon-steel guides and Alco Slidguide attachments are part of the equipment. The valve gear is Walschaerts, controlled by a Baldwin Type C power reverse gear.

Like the 4-8-4 type locomotives, the freight power is equipped with Baldwin disc driving wheels, 74 in. diametr over the tires. The second, fourth and back drivers have 12-in. by 13-in. journals, while the front and main axles have 12-in. by 14-in. and 15-in. by 13-in. journals, respectively. The driving boxes on the Nos. 1, 2 and 5 axles are the crown-bearing type with Franklin grease cellars. On the No. 1 axle the boxes are fitted with the Franklin lateral-motion device. The boxes on the Nos. 3 and 4 axle journals are Locomotive Finished Materials floating-bushing type.

The driving axles are normalized and tempered carbon-steel forgings, hollow bored with 5-in. diameter holes. Heat-treated nickel-chrome steel is used for the crank pins on the third and fourth pairs of drivers, while on the rest of the wheels the pins are heat-treated carbon steel. The main rods are of the Tandem type. Both main and side rods are of carbon steel, normalized and tempered, and floating bushings are used at the back ends of the main rods. A lateral-motion bushing is used at the front end of the side rod at the No. 1 driver.

Brakes and auxiliary equipment.

The brake equipment on these locomotives consists of the Westinghouse No. 8ET schedule with two 8 1/2-in. cross-compound compressors located on brackets back of the bumper beam. The engine and trailing trucks have no brakes. Air reservoirs, with a capacity of 77 959 cu. in. are located on brackets under the running boards. One 12-in. by 10-in. brake cylinder is provided for each pair of drivers.

A National Type E coupler is used at the front end of the engine and a Franklin A-1 radial buffer between the engine and the tender.

The headlight and generator were furnished by the Pyle-National Company.

Other equipment on these locomotives consists of Ashton steam and air gages, Crane cab and turret valves, Vapor cab heaters and train steam-heat equipment and Graham-White sanders. Flexible metallic connections are used on the air reservoirs, steam-heat connections and at the headlight generator, as well as on the oil and steam connections between the engine and tender.

The tenders.

The tenders for the freight locomotives are of the rectangular type with water capacity of 20 000 gall.

Copper-bearing steel is used in the tanks. On the oil-burning power the

fuel capacity is 7 000-gall. and provision is made in the tanks for 30 cu. ft. of flue sand. The coal-burning locomotives have no provision for sand and have coal capacity for 23 tons.

The tenders of the oil-burning locomotives are carried on two General Steel Castings six-wheel Pullman-type trucks — of the same design as used on the 4-6-3 and 4-8-4 passenger power. The coal burners have tender trucks built by the Buckeye Steel Castings Company which are interchangeable with those on the oil-burning locomotives. All 10 locomotives have 37-in. tender wheels and 7-in. by 13-in. plain-bearing journals. Unit cylinder clasp brakes with two 10-in. by 10-in. brake cylinders are part of the equipment on each truck.

The tender frames were cast by the General Steel Castings Corporation and are of the water-bottom type. The frames of the oil burners are arranged for conversion to coal as fuel.

The tender couplers, draft gears, yokes and uncoupling rigging were furnished by the National Malleable and Steel Castings Company.

MISCELLANEOUS INFORMATION.

[**621. 431.72 (.492)**]

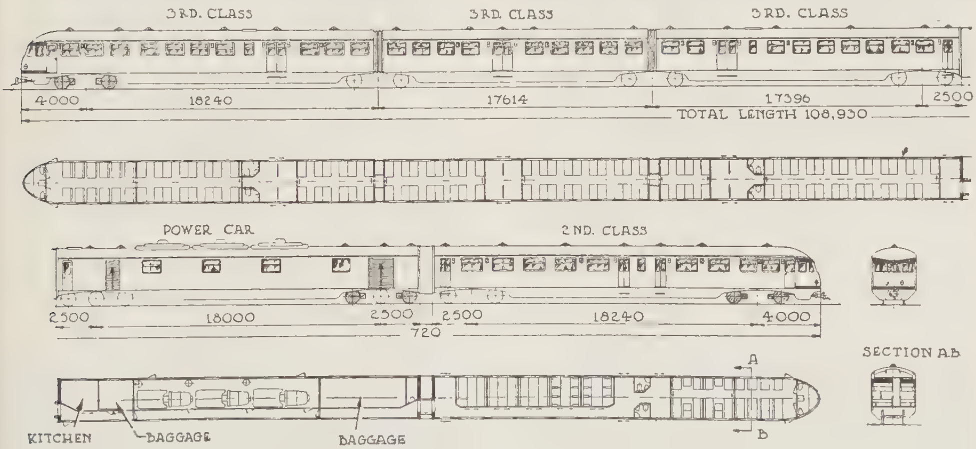
1. — New five-car diesel trains for Holland.

[Reprinted rom *The Oil Engine* (England), April 1939]

The 18 new five-car diesel trains ordered by the Netherlands State Railways last autumn are externally very similar to the electric three-car trains commissioned in 1938. The policy of the Railways is to maintain electric traction in areas with a very dense population and to speed up long-distance traffic by gradually replacing steam traction and obsolete vehicles by new streamlined and high-powered diesel express trains. Whilst the former 40 three-car diesel trains, which have already been in service for five years, have come up to all reasonable expectations for an initial big scale experiment, the new ones will consist of five cars instead of three, have more powerful machinery, and, of course, quite a number of minor improvements. In fact, with an overall length of 358 ft., they will be the longest diesel trains in Europe.

From the accompanying elevation and plan it may be observed that, starting at the left, the first six seats are arranged with a free forward view. The following compartments have the usual face-to-face seat arrangement. The three third-class cars are borne by four bogies and form a complete unit with cannot be separated in service. The fourth car consists of a kitchen, a small luggage compartment, the engine-room and a further main luggage section, a partition being necessary in order to locate the engines in the middle. Besides this there is a small staff compartment at the extreme end of the car.

The engines are not mounted on the bogies as it has been found that rail vibrations have a detrimental influence. In this matter Dutch engineers confirm the French experience that the life of an engine mounted on a bogie is only two-thirds that of an engine placed in the car.



In the new Dutch 376-passenger trains the power car divides second-class from third-class cars.

The power car is borne by two-six-wheeled bogies and the second-class car by two four-wheeled bogies. The arrangement allows an easy replacement of the power car in case of

repair or inspection. Noteworthy in the last car is the fact that two sections have a more luxurious equipment and might be used as first-class compartments if necessary. The last four seats are again arranged transversely in such a manner as to provide a panorama view.

The heating of the train is by warm air and the heat is obtained from the engine cooling system. Great attention has been directed to proper sound insulation, which has not always been efficient on diesel trains. The cars are built by the Werkspoor, Bevnes and Allan concerns, each of which produces the special types of car which form the complete train. The new railcars are designed for a speed of 100 m.p.h., although it is not the purpose to attempt to reach this speed in the first period of service. The complete train weighs 225 tons and provides accommodation for 276 sitting and a further 100 standing passengers, if required.

All 18 five-car trains will be propelled by three 100-B.H.P. Maybach-Büchi turbo-charged four-stroke units, but two reserve power cars have also been ordered and each of them will be fitted with two Ganz-Jendrassik diesel engines of 900 B.H.P.

All engines built in Holland.

The Maybach V-type engines mentioned above are built by Werkspoor and are practically the same as those used in the present Dutch railcars and in many German trains. They have two banks of six cylinders at an included angle of 60 degrees and their output has been raised by a 10-mm. increase in cylinder diameter (160 mm. instead of 150 mm.) and Büchi pressure charging from 410 B.H.P. to 600 B.H.P. at 1 400 r.p.m. The piston stroke remains unchanged at 200 mm. The engine, complete with the turbine-blower, weighs 2 300 kgr., or 5 100 lb., and has, therefore, a weight-to-power ratio of 8.5 lb. per B.H.P.

Outstanding features are the roller bearings for crankshaft journals and connecting rod big ends. Light alloy pistons are used and the connecting rods of one bank are forked to those of the other by articulating pins floating in bronze bushes. There are four valves per cylinder and the injection nozzle is mounted vertically in the head on the cylinder axis. Lubrication is by a gear-type pump and the oil is cooled by special pipes in the oil sump, through which a part of the blower air is directed, no special oil cooler being necessary. The two Deckel fuel pumps are fitted with dials constantly indicating the exact amount of fuel delivered. The governor is of the oil type and connected to the engine oil circuit. Besides controlling the speed of the engine it also serves as an emergency measure should oil pressure fail. A frictional torsion damper is fitted.

The turbo-charging equipment is mounted with its spindle vertical between the two banks of cylinders. It may be mentioned that owing to the excess of air for charging and scavenging, the exhaust gases are cooled, as also are the cylinder walls, pistons, valves, etc. The quantity of heat passing away through the cooling water is not greater than without turbo charging, as a part of the heat given up to the cylinder walls is directly absorbed by the cold scavenging air. A further advantage of this system is the exhaust noise damping effect of the blower. It is the intention to dispense entirely with silencers.

Fuel is stored in six tanks of 500 litres capacity each. Starting is effected by current supply to the generators from a nickel-cadmium battery of 300 amp.-hrs. capacity. The cooling system of each engine is outside the engine-room and consists of a horizontal radiator located beneath the floor and assisted by a fan, the whole being encased by a sheet-metal hood. The fan is driven from the generator and controlled by an automatic clutch, arranged in such a way that the fan is kept out of action at low water temperatures. Each water circuit has special heating elements in which warm water can circulate; it is obtained from two small boilers, which also serve for heating the two luggage compartments.

The five cars are propelled by six traction motors, two of which are placed in the front and two in the rear bogie, whilst the other two are located in one of the power-car bogies. Although the generators are not identical in the Büchi-Maybach power cars and

the Ganz-Jendrassik cars, as there are three in the first system and only two in the latter, the traction motors are similar. They are designed to run at 2 000 r.p.m. at a train speed of 160 km./h. (100 m.p.h.) and transmit the torque to the axle through a final 2 to 1.2 reduction gear. Each motor and gear casing, without the gears, weighs about 2 tons. The two motors in the front and rear « live » bogies are supplied by two different generators to prevent the complete failure of one power bogie in case of stoppage of one diesel engine. In addition to the main generator with an output of 375 kw., each diesel engine drives a supplementary generator of 25 kw.

The engines of the spare power cars are being built in the Netherlands by Stork, under the Ganz-Jendrassik licence. They have 16 cylinders in two rows of eight. With 185 mm. bore and 240 mm. stroke, the output is given as 900 B.H.P. at 1 350 r.p.m. The total engine weight is 5 600 kgr. (13.7 lb. per B.H.P.) A particular feature of the Ganz-Jendrassik engine is a very extensive use of the van der Horst chrome-hardening process which has been adopted for the cylinder liners, also the main and big-end bearings of the crankshaft.

The engine is fitted with Specialloid pistons. These have cast-iron piston ring groove inserts for the first compression rings.

[**621**. 592 (.75) & **625**. 241 (.73)]

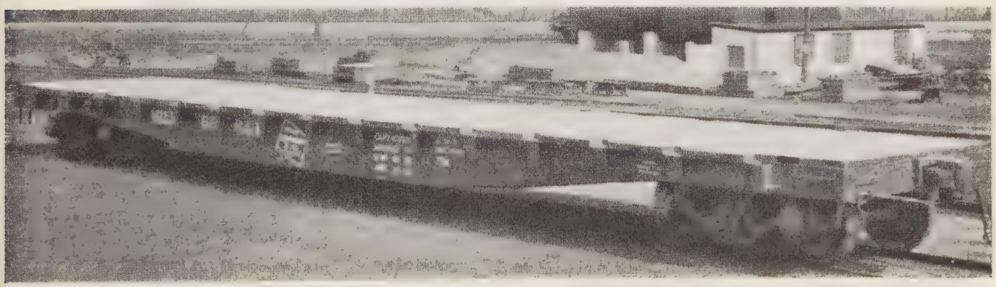
2. — Milwaukee 50-ton all-welded flat cars.

(Railway Age.)

A new series of approximately 500 all-welded flat cars are now undergoing construction in the Milwaukee shops of the Chicago, Milwaukee, St. Paul and Pacific. These cars are 52 ft. 6 in. long over the end sills, or 53 ft. 3 in. over the striking castings; have a capacity of 50 tons; and weigh approximately 45 600 lb. As in previous car construction programs on the Milwaukee, the principle of unit construction is being carried out, while the entire assembly is made on a production basis.

In the development of this flat car, the principal objectives have been to adhere to Association of American Railroad standards; conform to loading requirements; provide minimum initial and operating costs; and meet, as nearly as possible, shippers' requirements for this class of equipment. The unusually large deck, 52 ft. 6 in. long by 10 ft. 6 in. wide, is especially advantageous to manufacturers who desire to ship tractors, threshers and similar equipment requiring maximum-width cars.

The car has been designed from a welding standpoint throughout, using ordinary low-carbon steel, and stresses have been computed with a relatively high factor of safety. Stan-



Milwaukee 50-ton flat car just out of the shops.

dard mill sections, plates and bars with standard mill tolerances are employed and these have a definite bearing on cost reduction.

Owing to the substantial thickness of the plates used in the car, it has been necessary to use 1/4-in. and 5/16-in. welding rods except in isolated parts where 3/16-in. is used. The majority of the welding is intermittent with a ratio of 1:1 except in the region of the bolsters. Here, continuous welding is carried out using fillets of 1/4 in. Both transformer-type and motor-generator-type welding machines are being used.

In accordance with previous Milwaukee practice in building cars, separate jig assemblies for individual parts, such as bolsters, cross-bearers, center-sill sections and end sills have been adopted wherever possible. These fabricated units, progressively advanced on the production line, are then welded together to make up the final integrated steel assembly. In the subsequent positions, couplers, draft gears and air-brake equipment are applied. The trucks are assembled separately.

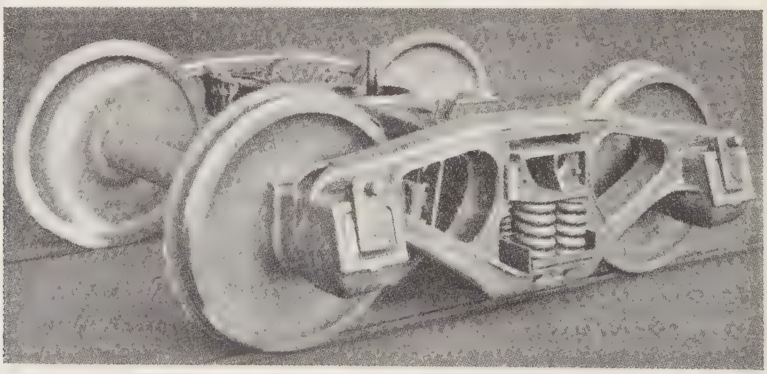
Fabrication of the principal structural units.

The center sills consist of two built-up sections, each comprising a web plate (cut to fish-belly shape), one upper chord angle and two lower chord angles. Each section is built up on a jig accommodating two, one of which is being set up while the other is being welded. This gives a high operating factor; i.e., per cent of time the arc is in operation; and since the majority of the welding is in a downhand position, maximum efficiency results. The completed sections are delivered by an overhead crane direct to the center-sill assembly jig. Here they are welded to a top cover plate while center-sill spreaders are welded on, center-filler and striking castings riveted in place and couplers and draft gears applied. This jig accommodates two such setups to cut idle time to a minimum.

Each side sill consists of a web plate (cut to fish-belly shape), one lower chord angle and a top cover plate. These are welded together on a jig built to take two such assemblies, and the 15 stake pockets are then welded to each sill.

Each end sill is composed of two channels which, in turn, are welded to a cover plate. This is accomplished in a revolving jig so that all welding is positioned. Grab irons, uncoupling castings and hand brakes are riveted on by means of a power riveter before the two parts are welded to the cover plate. This eliminates hand riveting and adds to the general efficiency. Separate jigs for the A and the B end sill are provided.

The bolster center-filler casting is a built-up, welded assembly, in which the center-plate casting is welded in place by means of tie-plates which, in turn, are welded to the forged bolster spider sides. This is likewise accomplished in a revolving jig.



The Barber type S-2 stabilized truck, using Bettendorf side frames

The cross-bearers are web plates welded to top and bottom cover plates. Each cross-bearer is assembled in two units on a specially constructed table. One unit consists of a continuous top cover plate, web plate and bottom cover plate while the other has the web plate and bottom cover plate only. In the final assembly the top cover plate passes through slots in the center-sill web plates and is welded in place. The bottom cover plates are welded directly to the center sills and, in order to make them continuous, a tie-plate is welded to the center sills across the lower chord angles.

Each bolster consists of two web plates, one top cover plate and one bottom cover plate. Between the web plates and welded to the bottom cover plate is the H-beam or side-bearing brace. A top cover plate is applied in the main assembly jig. Two revolving bolster jigs are used.

Assembly of units to form the completed car.

All individual units, having been manufactured, are taken to an assembly jig. The completed center sill is set up with the bolsters, cross-bearers, cross-ties, end sills and side sills and these parts are welded together into a single unit. During the welding operation, the side sills are held in place by means of eight air cylinders — four on each side of the assembly jig. The unit underframe, which is in an upside-down position, is then moved to the next jig where the piping and air-brake parts are applied.

After the welds have been peened and brushed, the car is placed right-side-up, put on trucks, and shunted into the paint booth for the initial priming coat. The latter is a quick drying paint with chromate base. From the painth booth, the car is moved to the adjacent track where car cement. on surfaces having metal and wood contact, floor stringers and boards are applied.

Select common fir is used for floor and stringers, while rough lumber 3 in. by 10 in., with milling sufficient only to surface and square the boards, is used for the flooring. To hold the latter in place there are six 1/2-in. flat head carriage bolts and four No. 4, 5 1/2-in. long steel wire nails per board. After the floors are applied, the cars are moved to the spray booth where they receive two coats of quick-drying freight-car paint. The final operation is application of the stencils and a rigid inspection of all parts.

In addition to the usual forged parts manufactured at Milwaukee shops, the following are also locally made : spring planks, spring plates, brake beams, wheels, brake shoes, thrust plates and brake-lever badge plates. The taper section of the web plates on side and center sills is shaped by the use of a portable motor-driven oxy-acetylene cutting machine. The chord angles are cold-formed in a press.

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WELDED METAL BRIDGES.

Comparison between the German and the French standard specifications.

(Case of the plate girder bridges)

by H. REGIS,

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(Annales des Ponts et Chaussées, France.)

INTRODUCTION.

The technique of assembling metal bridges by electric arc welding has developed to an extraordinary degree in Germany in the course of the last few years. Although welding was taken up later in Germany than in the United States, which was the pioneer country in this particular field, Germany has now undoubtedly assumed the leading place in so far as the welding of bridges is concerned.

In France, on the contrary, the development of welded bridges is comparatively slow, in spite of the fact that the French builders, not less than the engineers of the Administrative Services, are anxious to hasten this development. In particular France has not yet set forth in systematic form the advantages, as compared with riveting, which welding would appear to present according to the claims made by Germany.

Amongst the reasons which have been put forward to explain this divergence of opinion as between the two countries, the view has been expressed that the French specification was particularly strict; it is evidently an argument which, owing to the very nature of their profession, builders of metal structures will readily endorse, and the Technical Office for the Utilisation of steel (O. T. U. A.) has thought it of interest, therefore, to ascertain exactly how far this is true.

It is an indisputable fact that the French and German specifications have been drawn up on the basis of very different data and information.

In Germany, where the specification for welded metal bridges has already been revised on four occasions, the present official requirements are derived from a methodical and exhaustive series of experimental tests carried out over a number of years and bearing almost exclusively on the resistance which the industrial ferrous metals offer to the fatigue resulting from alternating stresses, a type of stresses having no doubt little effect on road bridges, but which must be taken into account when considering railway bridges.

Since, in France, exhaustive information based on experiment was not available, the engineers responsible for drawing up the French standard specification have not had any important laboratory information at their disposal for the preparation of this document. It is not to be wondered at, therefore, that these

engineers, when deciding the exact details of the specification (for which the heavy responsibility rests with them) should protect themselves by prudently imposing strict requirements.

This then is the question which the O. T. U. A. has decided to investigate impartially, and, let it be said, in no disparaging spirit, by means of a detailed comparison of the two above-mentioned specifications.

A difficulty arose at the very outset. The two specifications, which seem to speak different languages, are derived from basic principles which on the surface at any rate would appear to be different; it seems essential therefore to proceed by adapting language and symbols in such a manner that a clear and simple comparison may be made. With the help of certain hypotheses, and by the elimination of certain terms of little importance, it has appeared possible to transpose the French specification in a general way by adopting the form of the German standard specification. How this has been done is explained in the following pages.

The considerations which follow are restricted to plate girder bridges, as these are the only type dealt with by the present German specification.

Similarly the so-called high-resistance constructional steels (St. 52 and St. 54) have been disregarded, the inquiry being limited to the ordinary steels (St. 37 and St. 42).

I. — *Materials.*

We have set out below in tabular form the different characteristics of the French and German specifications in so far as the choice and control of the parent and deposited materials are concerned.

	FRENCH SPECIFICATION (St. 42 and St. 54).	GERMAN SPECIFICATION. (St. 37 and St. 52.)
Tests on parent metal and deposited metal.	The tests comprise: Tensile tests on test pieces entirely composed of deposited metal; Tensile tests on test pieces with welded joint. Bending tests. No cross weld test. (Cross weld tests are used when examining welders.)	The tests comprise: Tensile tests on test pieces entirely composed of deposited metal. Tensile tests on test pieces with welded joint. Bending tests. Cross weld test. (No distinction between tests for welders and tests of materials.)
Minimum tensile strength . .	Respectively 42 and 54 kgr./mm^2 (26.7 and 34.3 tons/sq. in.).	Respectively 37 and 52 kgr./mm^2 (22.9 and 33 tons/sq. in.).
Maximum tensile strength . .	Respectively 50 and 64 kgr./mm^2 (31.75 and 40.6 tons/sq. in.).	(No maximum tensile strength.)
Minimum elongation .	Respectively 18 to 20 %.	(No minimum elongation.)
Minimum resilience .	8 kgrm./cm^2 (373 ft.-lb./sq. in.).	(No minimum resilience.)
Endurance	(No endurance limit.)	Respectively: 15 and 16 kgr./mm^2 (9.5 and 10.2 tons/sq. in.) for transverse welds (not machined), 18 and 19 kgr./mm^2 (11.4 and 12.1 tons/sq. in.) for transverse welds (machined), and for longitudinal welds (after 1.8 × 10^6 pulsations).

The German specification does not enforce, as does the French, tests of the deposited metal each and every time that a new work is undertaken. A particular type of electrode is tested once for all by an official laboratory at intervals of two years. The constructor therefore has only to satisfy himself that the electrodes he uses conform exactly with the one which has passed the official test.

II. — *Fatigue of welds.*

In both specifications the maximum permissible fatigue for the deposited metal is obtained by multiplying the permissible stress for the parent metal by a coefficient α which varies according to the nature of the weld and the type of stress applied.

NATURE of the weld.	TYPE of stress.	COEFFICIENT α. French specification. In the workshop.	COEFFICIENT α. French specification. At the site.	COEFFICIENT α. German specification. In the workshop.	COEFFICIENT α. German specification. At the site.
Butt weld.	Tension	0.85	0,75	0,75	Not laid down.
	Compression	0.95	0,85	0,85	
	Bending	0.95	0.85	0.80	
	Shear	0.65	0,55	0.65	Same value as in the workshop.
Other welds.	All types of stress.	0.65	0,55	0,65	

III. — *Permissible stresses in the case of variable loads.*

The determination of the permissible stresses when the loads are variable differs greatly in the two specifications. The German specification takes into account factors which are ignored in the French, and which we will first of all summarize (1).

1. *German definitions.*

The following considerations, definitions, and notation form the basis of the German standard specification.

Let us consider a test piece of metal submitted to loads of variable magnitude on a pulsating machine. Let σ_u represent the absolute value of the minimum limit of the unit stress (kgr./mm²) resulting from these loads, and let σ_o represent the absolute value of the upper limit of this unit stress. Further we can distinguish the one value of these unit stresses from the other by an algebraic sign, namely plus (+) in the case of tension and minus (—) in the case of compression.

When σ_u and σ_o are of similar sign, we speak of *increasing* loads; when they are of opposite sign, we speak of *alternating* loads.

(1) Summary based on Kommerell's : « Notes concerning the requirements for welded structures in the case of railway plate girder bridges » (Berlin, 1936), the German notation being retained.

The interval $\sigma_o - \sigma_u$ is called the *range* of the alternation or of the pulsation.

WÖHLER and his successors have demonstrated that for every value σ_u of the lower limit of the pulsation, and for each value $\sigma_o - \sigma_u$ of the *amplitude* of that pulsation, there exists a number « N » of repetitions (range of fluctuation) above which number the test-piece invariably breaks. This number of repetitions before rupture « N » increases when the amplitude, i. e. the upper limit σ_o diminishes. When this number « N » attains the value 2×10^6, in many cases the test piece is unlikely to fail, even were the number of repetitions to be indefinitely increased.

The value of σ_o corresponding to this number of repetitions before rupture 2×10^6, is called the endurance limit, corresponding to the lower limit of unit stress.

In all that follows the symbol σ_o will systematically represent the endurance limit thus defined.

The endurance limit σ_v or σ'_v corresponding to a lower limit of unit stress of zero value ($\sigma_u = O$) bears the distinctive name of *primitive strength* or « repetition limit » stress (1).

The endurance limit σ_w such that it shall be equal in value but opposite in sign to the corresponding lower limit ($\sigma_o = -\sigma_u$) is called the *reversal limit* (1).

The results thus arrived at can be easily represented graphically (WEYRAUCH), by plotting the values of the minimum limits σ_u as abscissæ and the corresponding values of the endurance limits as ordinates, taking into account as usual the signs given to either of these two quantities.

By drawing the two bisectors of the

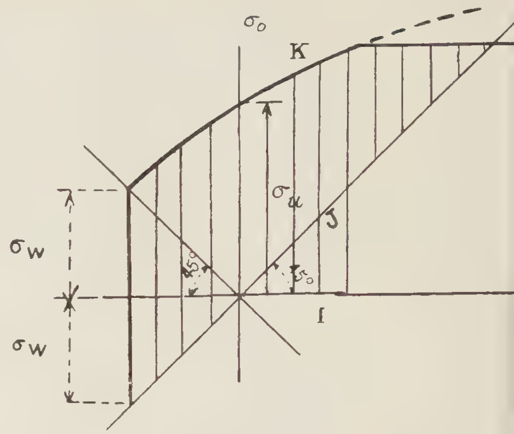

Fig. 1.

co-ordinate axes it is seen that for every value of σ_u, represented by the abscissa OI (fig. 1), there is a corresponding length JK set off as ordinate; this length JK represents the permissible range or amplitude for the corresponding oscillation.

Should the endurance limits σ_o be tensions, a graph such as that shown in Fig. 1 is obtained, in which the extent of oscillation is marked by vertical hatching.

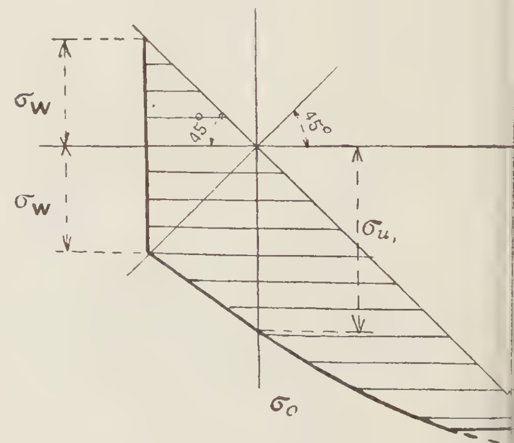

Fig. 2.

(1) Cf. MORLEY's « Strength of Materials ».

In the case of the endurance limits σ_0 in compression (fig. 2), the zone of oscillation is shown in horizontal hatching.

In practice the curves of the σ_0—'s are broken on the right side and do not exceed in height a line parallel to the axis of the abscissæ and distant from this axis by a quantity σ_F, which corresponds to the case where the values of the endurance limit reach the zone of permanent elongation for tension, or permanent crushing for compression.

On the left side, the curves of the σ_0—'s are limited as abscissæ to the value of σ_w, equal to the alternating strength.

For all practical purposes it can be assumed that the two portions of the curves (either for tension and for compression) bounded on the right by the horizontal limit σ_F, and on the left by the vertical limit σ_v, may each be replaced by two straight lines, which are not a production of one another, but diverge to the right and left by the values σ_v and σ'_v of the reversal limit in tension and in compression (fig. 3).

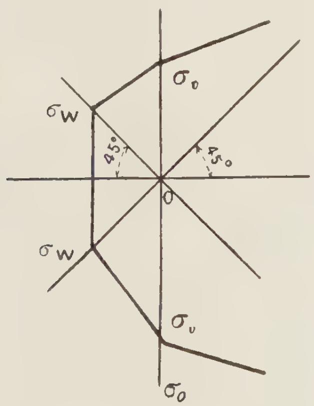

Fig. 3.

2. *German standard specification.*

This specification covering welded railway bridges is defined graphically by a certain number of diagrams, separately plotted for each of the different varieties of commercial constructional steel.

Each of these diagrams is plotted in accordance with the definitions and the method of experimentally measuring the terms σ_u and σ_0 which have just been described.

The numerical values taken for the term σ_0, from which the graphs in question are derived, are not the exact values of σ_0 obtained by experimental measurements, but the experimental values systematically reduced by 1 kilogramme per square millimetre ($\sigma_v = \sigma_0 - 1$).

The factor of safety given thereby results primarily from this reduction of 1 kilogramme/mm² (0.63 ton sq./in.), and is further enhanced by the fact that the experimental diagrams have been plotted for 2×10^6 alternations, whereas in actual practice the bridges will not be called upon to resist more than a quarter of this number of alternations in their lifetime.

There is naturally a diagram for the parent metal, and several other diagrams each corresponding to a definite type of weld.

Fig. 4 represents the various diagrams referring to the current German commercial steel (called St. 37); each of these diagrams corresponds to the following material and types of weld — the symbol *a* corresponds to the values σ_D in tension, and the symbol *b* to the values σ_D in compression :

Diagram I. — Parent metal. (i. e. unjointed plate).

Diagram II. — Butt-welded joint with a back run applied to the root of the weld, and the welds machined.

Diagram III. — Butt-welded joint, without a back run being applied.

Diagram IV. — Joints with front fillet welds, or near the extremities of side fillet welds, the edges of which have not been machined.

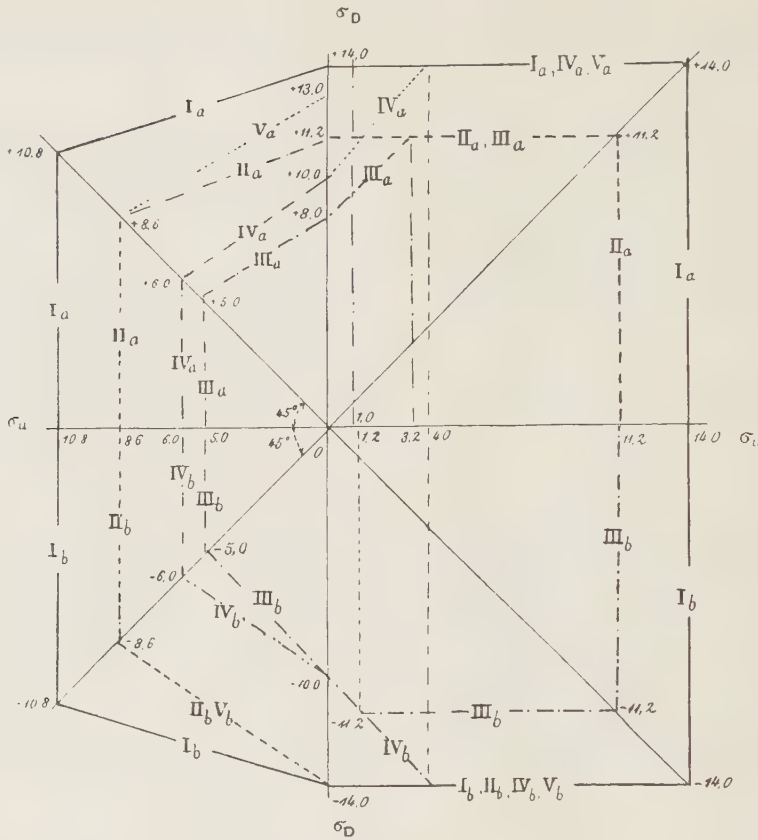

Fig. 4.

Diagram V. — Joints with front fillet welds, or near the extremities of side fillet welds, the edges of which have been carefully machined.

It should be noted in this graph that careful grinding of the edges of welds produced a marked increase in resistance. A comparison of Graphs II and III for butt welds, and Graphs IV and V for fillet welds, makes this immediately apparent.

Note furthermore, the superiority of very good fillet welds over very good butt welds (V and II) in the case where the absolute value of the maximum stress is tensile.

By virtue of their shape, each of the graphs in Fig. 4 is commonly known in Germany by the name « little house » (das Häuschen).

3. *French specification.*

This specification is based on the observation of the following inequalities :

(1) $c' + d'_1 + 0.5\,(d'_1 + d'_2) + t' \leqslant \alpha R_1$,

(2) $c' + d'_1 + 0.5\,(d'_1 + d'_2) + v' \leqslant \alpha R_2$,

(3) $c' + t' + w' \leqslant R_2$,

in which :

c' = Stress induced by the dead load;

d'_1 = Maximum stress, of similar sign to c', produced by the live load;

d'_2 = Absolute value of the maximum stress, of opposite sign to c' (if there is no stress of opposite sign to c', d'_2 will be taken as equal to zero);

v' = Stress induced by a wind of 150 kgr./m² (30.7 lb./sq. ft.) force;

w' = Stress induced by a wind of 250 kgr./m² (51.2 lb./sq. ft.) force;

t' = Stress due to the action of the temperature = Coefficient of reduction due to the weld; ;

R_1 and R_2 = Permissible limits of stress, depending on the nature and quality of the metal used.

In the case of French steel, so called « Ponts et Chaussées » quality (i. e. Ac. 42) which is the quality under review, the specification requires :

Tension and compression :

R_1 = 13 kgr./mm² (8.25 tons/sq. in.);
R_2 = 14 kgr./mm² (8.9 tons/sq. in.).

4. *Transposition.*

In order to make a simple and comprehensible comparison of the permissible stresses given by the French formulæ with those authorized by the German standard specification, let us try to represent the French formulæ in graphic form according to the German method.

Let us remark in the first place that the periods of the oscillations due to the temperature are infinitely longer than those of the oscillations due to the live load. On the other hand, the wind effect is considered in the calculations as a static load.

It is not unreasonable therefore to consider the terms v', w', and t' as being of the same nature as the stress c' resulting from the dead load, for the purpose of the comparison in question.

We must, however, be careful when making this comparison to consider in the French specification a 42 kgr./mm² steel as against a 37 kgr./mm² steel in the German specification. The rates of the permissible stresses R_1 and R_2 should therefore be proportionately reduced : R_1 from 13 to 11.45 kgr./mm² (8.25 to 7.27 tons/sq. in.) and R_2 from 14 to 12.33 kgr./mm² (8.9 to 7.8 tons/sq. in.).

These proportionate reductions are essential if one is to arrive at a fair comparison of the requirements of the two specifications.

Having said this, let us note that the above quoted inequality (¹), concerning tension may be written :

$$(c' + t' + d'_1) + 0.05 \times [(c' + t' + d'_1) - (c' + t' - d'_2)] \leqslant \alpha R_1,$$

If we remark moreover that the French expressions

$$c' + t' + d'_1$$

and

$$c' + t' - d'_2$$

are none other than the German expressions designated by σ_D and σ_u we may conclude that the above mentioned inequality may be written :

$$\sigma_D \geqslant \frac{2\alpha R_1 + \sigma_u}{3} \qquad R_1 = 11.45$$

which transcribes in German terms the requirements of the French standard specification.

Applying similar treatment to inequality (2), we are able to write :

$$\sigma_D \geqslant \frac{2\alpha R_2 + \sigma_u}{3} \qquad R_2 = 12.33.$$

If we reproduce these two inequalities in graphic form by means of a Weyrauch diagram we obtain a series of « little houses » whose outlines vary according to the values of α.

In Fig. 5 have been shown only the graphs corresponding to the more fa-

(¹) Strictly speaking one should take into account the variations of t'. But in general they are sufficiently slight to be ignored, in comparison with the variations in stress due to the live load.

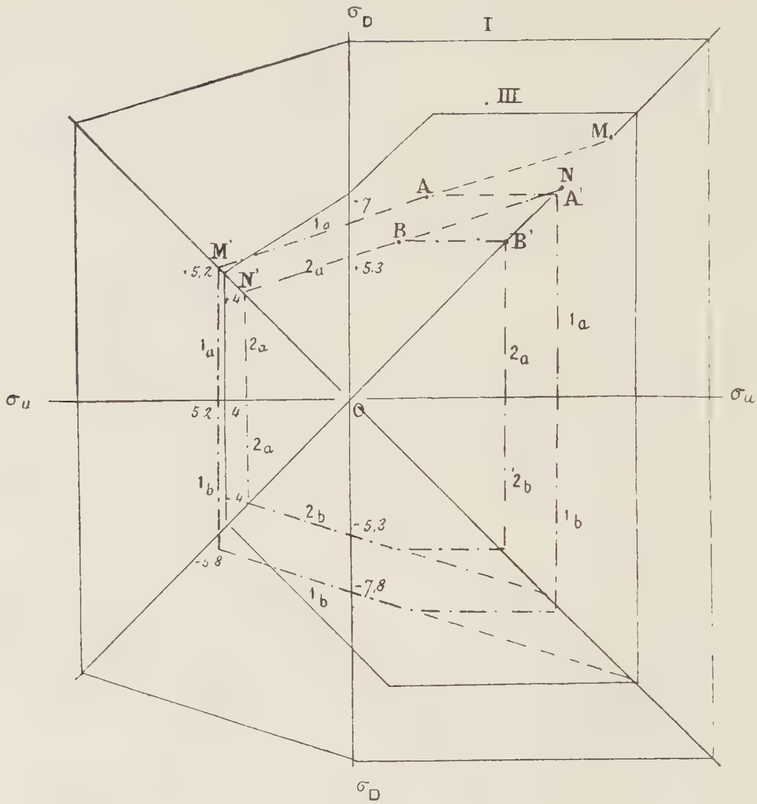

Fig. 5.

Key : Full lines represent graphs derived from the German specifications, corresponding to the parent metal (Graph I), and the poorest type of weld (Graph III).

vourable inequality, i. e. the second, with $R_2 = 12.33$.

These graphs are drawn to exactly the same scale as those of Fig. 4.

Diagram I corresponds to butt-welds.

Diagram II corresponds to fillet welds.

This latter diagram is dissymmetrical with reference to the axis of the x—es, as is to be expected, since α does not keep the same value when changing from tension to compression.

It should be noted that the above-mentioned equations only give the oblique portions (MM' and NN') of the « little houses ». The horizontal portions AA' and BB' are determined by the fact that d'_2 is considered as zero if there is no stress of sign opposite to c'. This means that commencing with a certain value of σ_u equal to $c' + v'$, the permissible σ_D keeps a constant value equal to :

$$\sigma_D = \frac{2\alpha R_2 + c' + v'}{3}.$$

5. *Comparison of the two specifications.*

It can be concluded from a casual glance at the comparative graphs in Figs. 4 and 5, that the French specific-

ation acts as a serious deterrent to builders of welded bridges.

Welding is burdened not only with the general coefficient of reduction α, but further with the term 0.5 $(d_1 - d_2)$ which occurs in the formulæ, and which moreover is not found in the general formula of the French standard specification for riveted bridges (1).

In addition the French standard specification does not take into account the numerous results of endurance tests which prove that a grinding of the welds after deposit substantially increases the resistance to fatigue of the welded joints by doing away with the « notch » effect particularly injurious in stresses of this character.

Whatever the cause the best of welds in France is considered nearly inferior to the worst of welds in Germany.

It is worthy of note that the graphs derived from the French specification present approximately the same shape (the scales being similar) as the experimental diagrams of the German specification. This circumstance, the result no doubt of a fortunate coincidence, may serve as a help towards bringing into line the requirements of the two specifications.

Thanks to the obligations imposed in France as regards quality alike for parent metal, electrodes, and the standard of workmanship of the welders, it is unlikely that the welds made in our workshops are inferior to those made in the German shops (always excepting the careful grinding of the welds after deposit). Under these circumstances there would appear to be ample grounds for relaxing the strictness of the French standard specification.

With this end in view, whilst adhering to the method of notation by arithmetical inequalities, to which the French engineers are accustomed, one could :

Either replace the term 0.5 $(d'_1 - d'_2)$ by another function of these two quantities, which would be of lower value, and which should furthermore keep the transposition diagrams similar in shape to the German diagrams; in this case the values of the coefficient α would remain unchanged. This is an investigation which we have not undertaken;

Or, preserve in their existing form the first members of the inequalities (1) and (2), whilst replacing the coefficient α in the second member by a new coefficient β, the numerical values of which would be suitably adapted to the various cases.

Considering this second method of transposition and taking a value $\beta = 1$ in the case of butt welds, the immediate result is that the transposition diagram derived from the French formulæ can very nearly be superimposed on the German diagram corresponding to butt welds of the poorest quality.

Modifications of this nature may possibly be criticised on the ground that they are purely empirical. However, this objection should have little weight provided such modifications lead us to results which are being constantly verified in actual practice. In fact, the German standard specification which has proved satisfactory in spite of its liberality, can scarcely claim to have been arrived at by any other method.

(1) For this latter type of bridge, the formulæ of the French standard specification are:

$$c + d + t \geqslant R_1.$$
$$c + d + t + v \geqslant R_2.$$
$$c + t + w \geqslant R_2.$$

In these inequalities the symbols have the same meaning as the same symbols (with accent) occuring in the specification for welded bridges.

[625. 113]

Railway Curves. — Junctions.

Problems of layout. — Junctions with transitioned turnout-curves

by J. CHAPPELLET,

Assistant Engineer, Central Permanent Way Service, French National Railways Company (Northern Area.)

(1) High speeds over the through and branch roads.

Let us consider the case of a junction in which the through roads AB, CD, of the two turnouts are laid on the straight, and examine a vehicle which travels over the two branching-off roads AE, CF.

This vehicle, when on the left-hand track, passes first over the straight portion MA, then the branch AE, in the facing direction, then the connecting curve EG, and then the diamond-crossing GH, (which we will assume to have different angles).

On the right-hand track the vehicle traverses the branch road CF, in this track, in the trailing direction, and afterwards the straight portion CP.

It is obvious that the passage of this vehicle at high speed will be comfortable only if the path which it pursues contains no objectionable changes of curvature, so that the resulting changes of acceleration are imperceptible to passengers standing in the corridor of the vehicle.

In order to arrive at such an alignment, there are three conditions which must be satisfied.

It is necessary in the first place for the radii of curvature of the turnout AE, of the connecting curve EG, and of the diamond-crossing, either to be equal, or, for their differences to be such that :

$$f_2 - f_1 \leqslant \frac{8.6}{v^2}$$

f_2 and f_1 being the versines of the two adjacent curves, and v the speed in metres per second [1].

Further, the shock of entry into the curve, at A and at F, and of exit at H, and at C, must not give rise to jolts detrimental to the comfort of passengers. Finally, the switch angle of each turnout should be zero.

We will now consider how far it is possible to satisfy these various requirements.

In order to reduce the shock of entry into the curve at A, there are two possible solutions; either, make the radius of the turnout curve equal to at least 2 000 m. (100 chains), or let the turnout curve become a parabolic transition, the curvature of which is zero at A and equal to $\frac{1}{R_1}$ at E ; R_1 being the radius of the curve EG.

The first solution has the drawback of necessitating an appreciable change of radius at E, as the radius of the curve EG cannot as a rule be made more than 500 to 700 m. (25 to 35 chains) on account of the rather restricted track intervals (six-foot way) usually encountered.

[1] See *Bulletin of the Railway Congress*, October 1930.

If the radius of the curve through the diamond crossing is in the neighbourhood of 1 000 m. (50 chains) and the radius of the turnout curve is to be in the neighbourhood of 2 000 m. (100 chains), the curve EG must take the form of a parabolic transition, the curvature of which will vary from 1/2 000 to 1/1 000, and the average curvature will be 1/1 330, which will still require too great a track interval.

We are of the opinion, therefore, that the second solution is to be preferred and that the alignment of the turnout curve of the connection between the left-hand roads should be a parabolic transition.

In order to eliminate the shock of exit from the curve at H, it is sufficient either to let the diamond crossing be followed by a curve of the same radius as that of the diamond crossing itself, or to suitably connect the curve of the diamond crossing either to the straight or to some other curve of appreciably different radius which may follow it.

Adopting for the connection in the right-hand roads a turnout curve of radius at least equal to 2 000 m., the shock of entry at F, when the turnout is preceded by a length of straight, and the shock of exit at C, will both be negligible. In the case where the turnout curve is either preceded or followed by a curve of radius appreciably different from 2 000 m., the turnout and this curve should be joined by a transition.

So far as the switch angles are concerned the construction of the switches does not admit of these being made zero. They should, however, be reduced as far as possible. The values selected depend partly on decisions regarding the clearances required between stock rail and switch tongue (the length of the latter being restricted to about 14 or 15 m. (46 to 49 ft.), and partly on the thrust produced when a vehicle traverses them at high speed, the magnitude of this thrust being measured by means of accelerometers.

These considerations led us, at the end of 1930, to entertain the idea of a junction with a turnout road taking the form of a parabolic transition (fig. 15), the calculations for which are given at the end of this article (Note 1).

This simple idea, logical though it is, now that there is no longer any question of the necessity for parabolic transitions in main line curves was not pursued at an earlier stage owing to the belief that the switch angle [1] alone was responsible for the objectionable jolt at the entry to the switches.

Now, it is also possible to conceive that the shock of entry into a curve, of average radius [2] without parabolic transition, may in fact be the principal cause of this jolt.

We would remark that, so far as we are aware, measurements of accelerations at switch angles and at the tangent points of un-transitioned curves, as part of the study of switches and crossings, had not previously been attempted at that time. And yet accelerometers had been available for a long time, notably the Auclair (mass-type) which would have enabled such information to be obtained with quite sufficient accuracy. As an experiment, a transitioned turnout with a switch angle of 0° 45' 0" was designed, (although the standard switch angle of 0° 51' 34" was retained for general use). Firstly it was ascertained experimentally

(1) The switch angle in use on the System at that time, for junction switches, was 0° 51' 34".

(2) The radius in use on the System at that time, for non-symmetrical turnouts, was 736 m. (37.8 chains).

that a switch tongue 12 m. (39 ft. 4 1/2 in.) long would enable the requisite flangeway clearances between tongue and stock rail to be maintained, with a single stretcher bar for driving purposes.

With the object of improving the riding at speed over the junction at Longueau (Signal Box No. 1), the two connections of the double junction, having

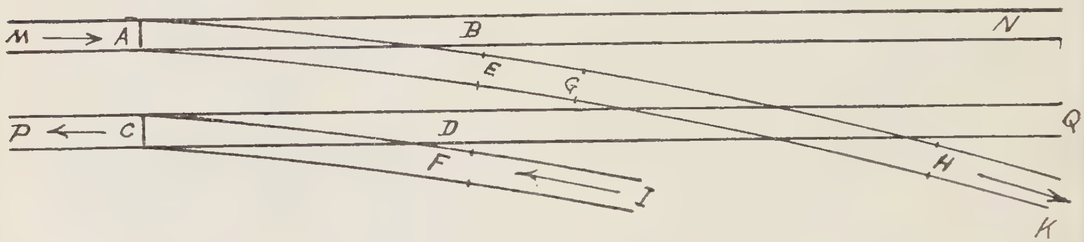

Fig. 1.

turnout curves of 736 m. (36.8 chains) radius, a switch angle of 0° 51' 34", a crossing angle of tan 0.06, arranged as shown in Fig. 1, were replaced by two connections with transitioned turnouts, in the same position.

In order to make a comparison between these turnouts, tests, involving measurements of acceleration, were made at high speeds on the junctions with circular turnout curves and on those with parabolic transitions. We will now set forth, and analyse, the results of these tests.

Running tests at high speeds on circular turnout curves of 736-m. (36.8 chains) radius (1) of the tan 0.06 connections of Longueau Junction (Signal Box No. 1).

In the first place we would draw attention to the fact that the switches of the turnouts with circular curves being superelevated 0.09 m. (3 1/2 in.) throughout their length were preceded, on the straight portion, by a cant developing gradient 125 m. (410 ft.) long, on which the superelevation increased at the rate of 1 in 1 000, being eased off slightly at the toe of the switches.

Running on the left-hand road. — Speed 100 km. (62 miles) p. h. — Switch taken facing.

The rearmost vehicle, in which the Mauzin-Langevin piezo-electric quartz accelerometer was placed, was a coach of wooden construction, with bogies 13.68 m. (44 ft. 10 in.) apart, and weighing 40 tons, and the accelerometer was stationed over the rear bogie. On account of the cant gradient on the straight track in front of the switches, on which the 90 mm. (3 1/2 in.) of superelevation is attained, the vehicle is in contact with the running edge of the low rail, from the point where the superelevation reaches 70 mm. (2 3/4 in.) up to the toe of the switch tongue (Fig. 2) (1). Between the moment the vehicle runs over the toe of the tongue, and the moment when the shock of entry into the curve makes itself felt in the body of the coach, a cer-

(1) In practice 736 m. (36.8 chains) is only a theoretical figure, owing to imperceptible deformations; the radius of the turnout curve may be appreciably less than this at certain points.

(1) The acceleration curves have been plotted to the following scales : 1 mm. to the metre (1 in 1 000) for distances g = 23 mm.

tain interval must elapse while the play of the wheels on the track and the lateral play between the bogie and the coach are taken up.

About 4 m. (13 ft. 1 1/2 in.) from the toe of the tongue, at the end of the short length of straight at the toe and tangent to the curve of 736 m. radius, the coach body is subjected to an initial acceleration of approximately $g/4$ which rises to $g/3 = 2.50$ m. (8.2 ft.) beyond. *Then, in 1/30 sec., the acceleration changes abruptly from* g/4 *to* g, *representing a change in acceleration of 22*g *per second.*

This is the effect of the shock of entry into a curve without parabolic transition. Damping takes place rapidly. Thereafter, on account of the lack of superelevation for the speed and radius of the curve, the vehicle clings to the outer rail, due to the centrifugal force which fluctuates about a value of $g/2$.

Running on the right-hand road. — Speed 110 km. (68.3 miles) p. h. — Switch taken trailing.

The rearmost vehicle, in which the Mauzin-Langevin piezo-electric quartz accelerometer was placed, was a coach of wooden construction, with bogies 13.68 m. (44 ft. 10 in.) apart, and weighing 40 tons, and the accelerometer was stationed over the rear bogie. After traversing the switch (Fig. 3) the wheels which are running on the high rail, strike the latter at a point 8 m. (26 ft. 3 in.) beyond the toe of the switch by reason of the change of direction, by which point the lateral play between the high rail and the components of the vehicle has been taken up.

This thrust gives rise to an acceleration of $g/2$. The vehicle then rebounds on to the low rail which it strikes in a

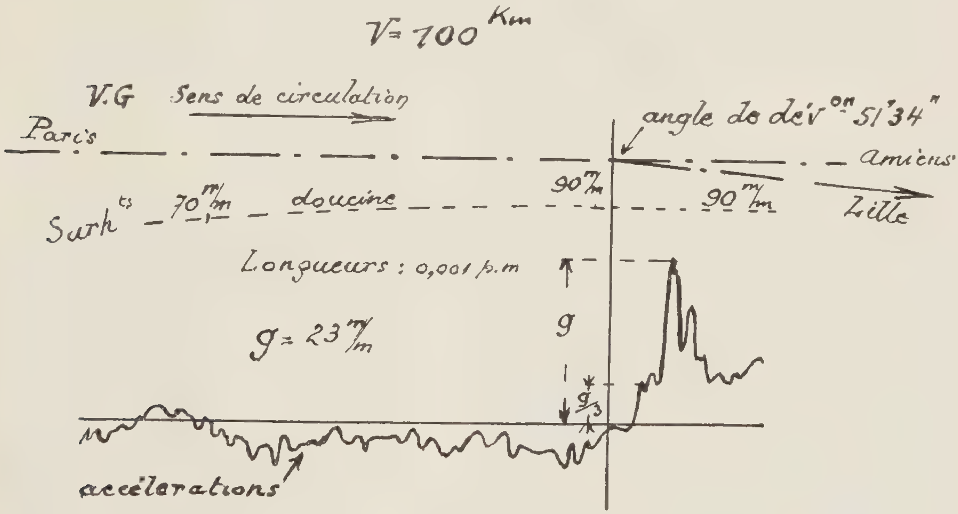

Fig. 2.

Explanation of French terms:

Sens de circulation = direction of travel. — Angle de dev^on = switch-angle. — Doucine = easement. — Surh^ts = superelevation. — Longueurs : 0,001 p. m. = distances, 1 in 1 000 scale.

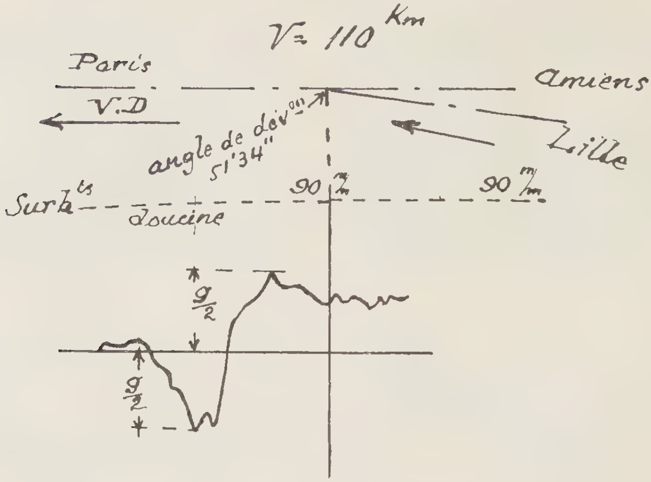

Fig. 3.

similar manner with an acceleration of $g/2$ approximately.

This hunting motion dies away rapidly. In addition, at the exit from the turnout curve, the sudden removal of the centrifugal force and of the superelevation of 90 mm. (3 1/2 in.) on the straight portion, sets up in the suspended coach body a rolling motion, as seen in the extract from the Hallade record (Fig. 4) which reveals an oscillation of 60 mm. (2 3/8 in.) amplitude.

Running tests at high speed over the parabolic transitions of the new turnouts at Longueau Junction (Signal Box No. 1).

We will first describe the characteristics of the turnout with parabolic transition. This turnout of a total length of 62.68 m. (205 ft. 8 in.), consists of a switch with tongues 12 m. (39 ft. 4 1/2 in.) long, the switch angle being equal to 0° 45' 00". The turnout curve conforms to a transition varying from radius ∞ at the origin to 810 m. (40.5 chains) at the end. The crossing, of manganese steel, is of the « Est », dou-

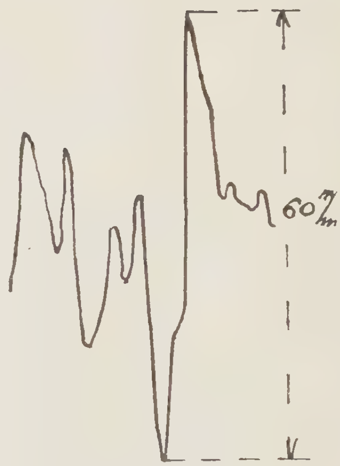

Fig. 4.

ble-angle pattern, angle tan 0.045 on the wing-rail side, and angle tan 0.05 on the Vee, these angles being connected, theoretically, by a curve of 1 300 - m. (65 chains) radius.

Running on the left-hand road. — Speed 100 km. (62 miles) p. h. — Switch taken facing.

At the first trial the superelevation at

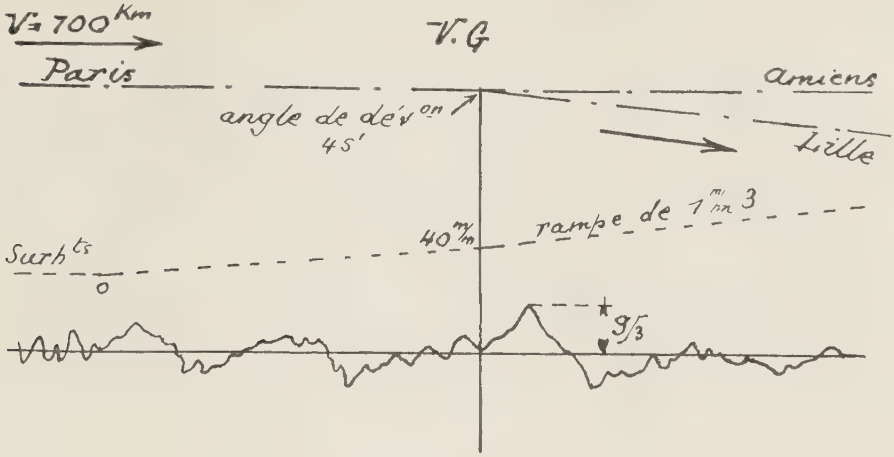

Fig. 5.

Note. — Rampe de... = rising gradient of...

the toe of the switch was 40 mm. (1 9/16 in.) (Fig. 5). The rearmost vehicle in which the Mauzin-Langevin quartz piezo-electric accelerometer was placed, was a coach of wooden construction, with bogies 13.68 m. (44 fr. 10 in.) apart, and weighing 40 tons. The accelerometer was stationed over the rear bogie.

On the straight portion, the superelevation at the toe of the switch tongue being considerably less (40 mm. instead of 90 mm.) than in the turnout with circular transition, and the cant gradient in front of the switches being correspondingly shorter, the vehicle did not cling to the low rail. On 5.50 m. (18 ft. 1/2 in.) beyond the toe of the switch (Fig. 5), the acceleration varies, as in the case of the switch of the circular turnout curve, from 0 to scarcely $g/3$.

This is explained by the fact that the switch angles of the two types of switches are practically the same, their tangents differing by only 2 mm. per metre (1 in 500). But for several metres beyond, the parabolic transition practically coincides with a straight line, the shock of entry into the curve does not occur, while the acceleration diminishes progressively over 5.50 m. (18 ft. 1/2 in.), becoming negative in that portion of the turnout curve where the superelevation is in excess of that required for the curvature on account of the speed. The vehicle then travels freely, as if on straight track, as far as the crossing.

This test gives us, with sufficient accuracy, the centrifugal acceleration due to a switch angle of 0° 45' to 0° 51', situated in track with 40 mm. (1 9/16 in.) of superelevation.

The second test was made with a superelevation of 59 mm. (2 21/64 in.) at the toe of the switch. The acceleration diminished appreciably and became $g/4$ at the switch (Fig. 6). Elsewhere the general form of the graph remained the same. The variation of the acceleration was not more than $g/4$ in 1/7th second, or $\frac{7g}{4}$ per second.

Now, in the turnout with circular curve the change of acceleration was $22g$ per sec.; the jolt was thus approximately 13 times less powerful in the case of the turnout with parabolic transition.

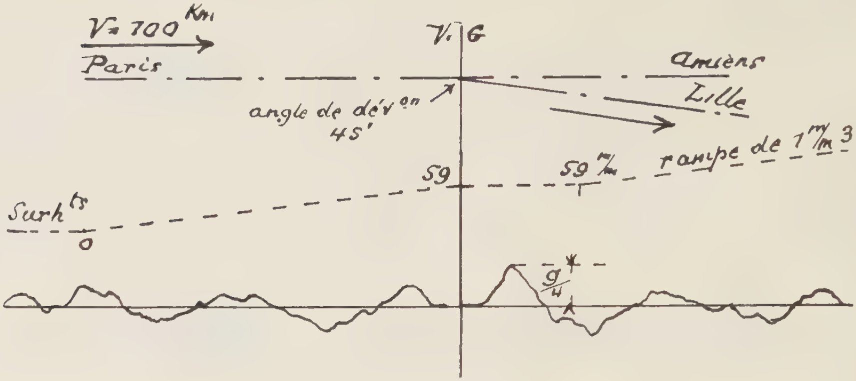

Fig. 6.

Running on the left-hand road. — Speed 110 and 120 km. (68.3 and 74.6 miles) p. h.

At 110 and at 120 km. the acceleration curves were very little different (Figs. 7 and 8).

The transit of the switch angle took place as already described although the variation is a little more rapid and more irregular than at a speed of 100 km. p. h. The acceleration rises to $g/3$ at 5 m. (16 ft. 5 in.) from the extremity of the switch tongue, and then decreases at an average rate of $2g$ per second.

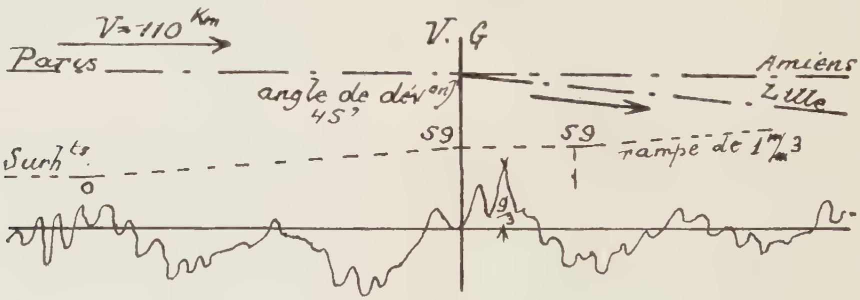

Fig. 7.

Running on the right-hand road. — Speed 110 km. (68.3 miles) p. h. — Switch taken trailing.

The first test was made with a super-elevation of 30 mm. (1 3/16 in.) at the toe of the switch. The rearmost vehicle, in which the Mauzin-Langevin piezo-electric quartz accelerometer was placed, was a coach of wooden construction, with bogies 13.68 m. (44 ft. 10 in.) apart, and weighing 40 tons. The accelerometer was stationed over the rear bogie.

On the parabolic transition curve, the vehicle travelled practically as on straight

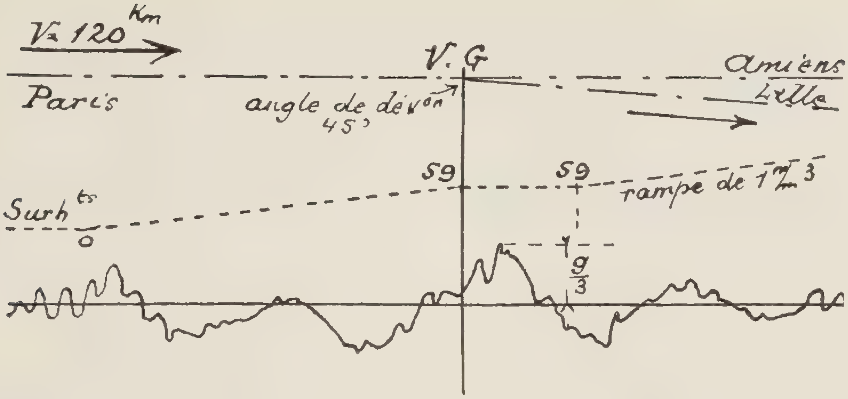

Fig. 8.

track (Fig. 9); on traversing the switch-angle, at 7 m. (22 ft. 11 5/8 in.) from the switch tongue toe, towards Paris, all the lateral play between the outer rail and the various parts of the vehicle being taken up, as in the case of the turnout with circular curve, the vehicle first strikes the outer rail with a force proportional to $g/2$, then rebounds towards the inner low rail which is struck with a force proportional to $g/3$.

The hunting motion thus set up rapidly dies away. Consequently from the point of view of the magnitude of the accelerations, the improvement obtained over the turnout with circular curve is negligible. But at the toe of the switch tongue, where the parabolic transition curve has ended, the suspended coach body is no longer acted upon by centrifugal force, and further, the superelevation is only 30 mm. (1 3/16 in.); con-

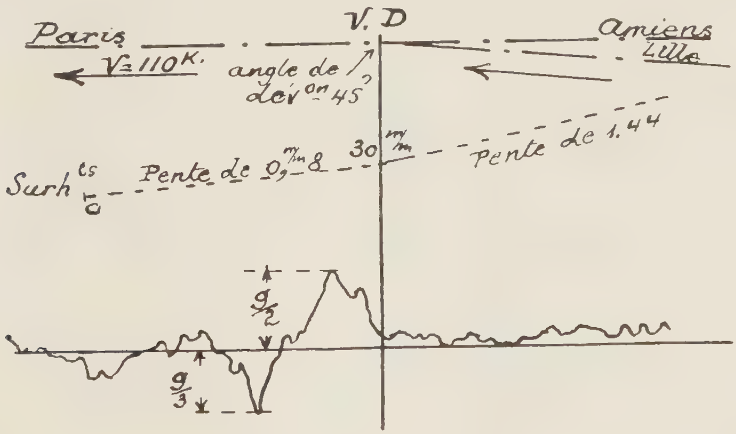

Fig. 9.

Note. — Pente de... = falling gradient of...

sequently the coach no longer acquires the rolling motion which it had with the circular turnout curve, and, as the extract from the Hallade record shows, the oscillation of the pendulum is no more than 27 mm. (1 1/16 in.) in amplitude, instead of 60 mm. (2 3/8 in.) (Fig. 10).

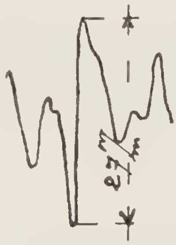

Fig. 10.

For the second test, the superelevation was increased from 30 mm. (1 3/16 in.) to 52 mm. (2 1/16 in.) at the toe of the switch.

After having traversed the switch angle, the vehicle acquires the hunting motion previously noted (Fig. 11).

The initial acceleration, corresponding to the blow on the outer rail, reaches $\frac{2g}{5}$, while the second acceleration, measuring the blow on the low rail is equal to $g/2$. The increase in superelevation does not therefore bring about any improvement.

As to the Hallade record, this resembles the one seen in Fig. 10.

For this test and for the following one, the rearmost vehicle, in which the piezo-electric quartz accelerometer was placed, was a coach of wooden construction, with bogies 12.63 m. (41 ft. 5 in.) apart, and weighing 34 tons, which is a little different from the preceding one. Notwithstanding this difference, we consider that the results obtained are comparable with those obtained with the 40-ton coach.

By comparing the results of the tests carried out on the right-hand road at a speed of 110 km. for the turnout with circular branching-off curve and that with a parabolic transition curve, we find that with the latter the rolling motion is very slight, the hunting motion remains, but the second blow is somewhat less severe, since the acceleration corresponding thereto is equal to $g/3$ instead of $g/2$.

To sum up : at speeds of 100 and 110 km. (62 and 68.3 miles) p. h., the turn-

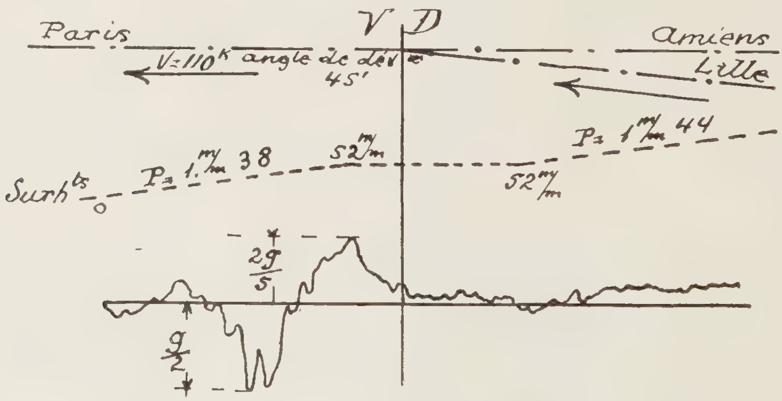

Fig. 11.

out with a parabolic branching-off curve, on the left-hand road, is clearly superior to that with a circular curve; the jolt at entry in the facing direction is 13 times less severe. On the right-hand road the accelerations at the exit from the switches have the same magnitudes but the rolling motion has become quite reasonable.

Running on the right-hand road. — Speed 120 km. (74.6 miles) p. h.

The superelevation amounted to 52 mm. (2 1/16 in.) at the toe of the switch tongue. The passage of the switch angle, in the trailing direction, takes place in the manner already described (Fig. 12). The acceleration corresponding to the blow on the outer rail is $g/2$, its variation and actual magnitude being comparable with the results obtained at the speed of 110 km. p. h.

The acceleration corresponding to the blow on the low rail amounts to $\frac{2g}{3}$. This value is greater than that for 110 km. p. h. when it only reached $g/2$, and the rate of change is a little more rapid.

The rolling motion seemed to be no greater than at the speed of 110 km. p. h., the Hallade pendulum record being almost identical with that obtained at the latter speed.

Improvements to be made to the layout of turnouts with parabolic transition.

The tests we have just described and discussed, demonstrate : (1) That the switch angle of 0° 45' 0", for a given superelevation and track gauge, and for a vehicle with a given type of suspension and degree of bogie play, gives rise to an acceleration of $g/4$ at a speed of 100 km. (62 miles) p. h., and $g/3$ at a speed of 120 km. (74.6 miles) p. h., the switch being traversed in the facing direction. (2) That at about 12 m. (39 ft. 4 1/2 in.) beyond the vertex of the switch angle the acceleration fluctuates about zero throughout the parabolic transition curve.

The effect of the switch angle is therefore isolated and consequently likely to be particularly noticeable. At the same time, over the rear wheels of the vehicle

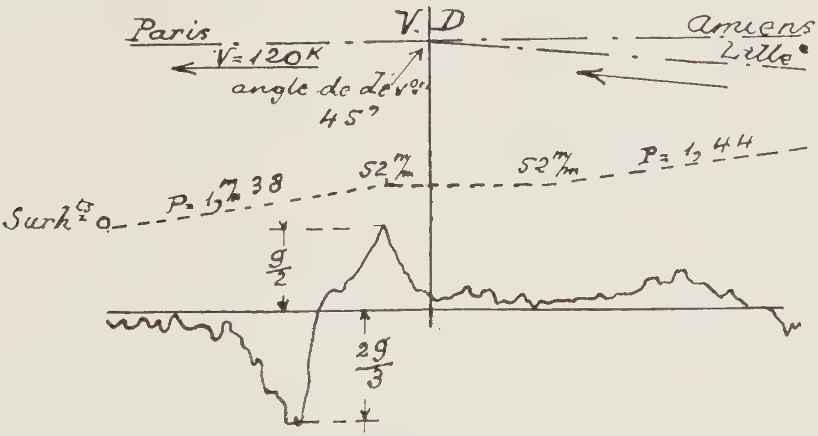

Fig. 12.

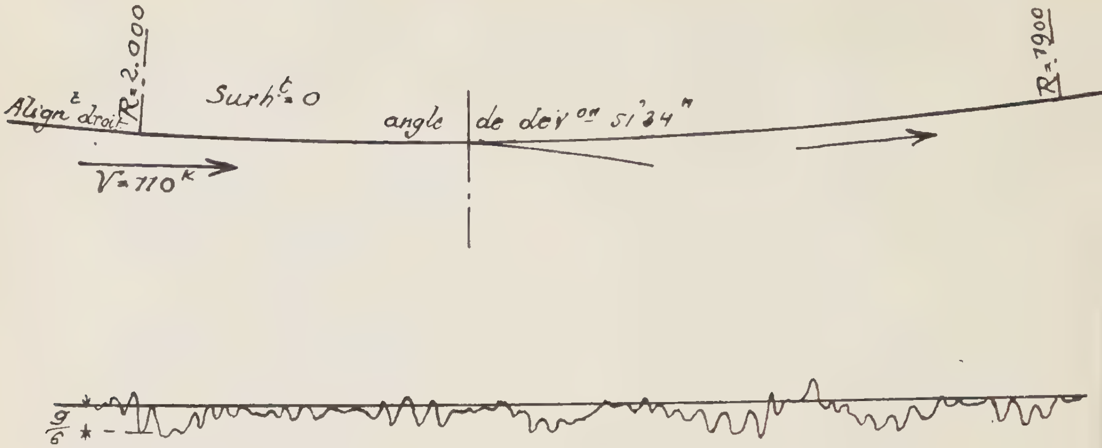

Fig. 13.

attached to the rear of the train, at a speed of 100 km. p. h. it is hardly perceptible, while at 120 km. p. h. its influence is no longer quite negligible. In a coach in the middle of the train, no effect at these two speeds can be felt by a passenger standing in the corridor. Nevertheless there is no doubt that a reduction of the switch angle is worth while.

To put such a reduction into effect means increasing the length of the turnout, as well as the length of the switch tongues, and there may be objections to increasing the latter beyond 15 m. (49 ft. 2 1/2 in.). Since the passage of the switch angle will always set up an acceleration, it seems useless to make the turnout curve immediately following the switch angle, of infinite radius, the acceleration for which is zero.

From the dynamic point of view it seems preferable to adopt for the turnout a transition curve the curvature of which at the origin generates a centrifugal acceleration (including that from the shock of entry into the curve) equal to that due to the switch angle. If the switch angle and the transition curve are suitably matched, a slight but uniform acceleration occurs for an appreciable distance along the turnout curve, instead of having at a single point on the turnout curve an isolated, and therefore more noticeable, maximum acceleration.

When travelling at 110 km. p. h. over a curve of 2 000 m. (100 chains) radius [1], without parabolic transition or superelevation, we find that at the tangent point, the shock of entry into the curve is equal to $g/6$ approximately (Fig. 13).

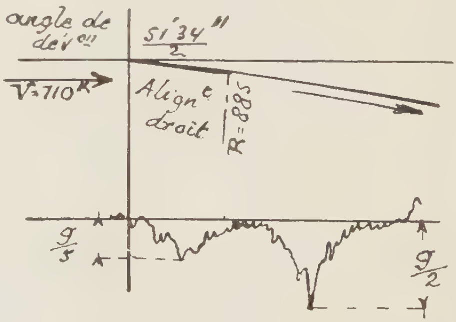

Fig. 14.

(1) The accelerometers were placed over the rear bogie of the rearmost vehicle, which was of wooden construction, with bogies 13.68 m. (44 ft. 10 in.) apart, weighing 40 tons.

On the other hand, the acceleration produced by travelling at the same speed through a switch-angle of 0° 25' 0" laid without superelevation, is equal to $g/5$ approximately (Fig. 14).

One can therefore tentatively adopt 1/3 000 as the curvature at the commencement of the parabolic transition; this allows a certain margin to cover possible local reductions of the radius of curvature, by distortion, immediately beyond the switch angle.

The foregoing considerations led us, in 1938, to suggest a new double-track junction having a turnout curve conforming to a parabolic transition, Fig. 16, the calculations for which are given at the end of this article (See Note 2). We believe that this type of turnout will permit of travelling through the branching-off roads at a speed of 120 km. (74.6 miles) or even 140 km. (87 miles) p. h. without appreciable jolts.

Turnouts with parabolic transitions, may also be laid in the following manner :

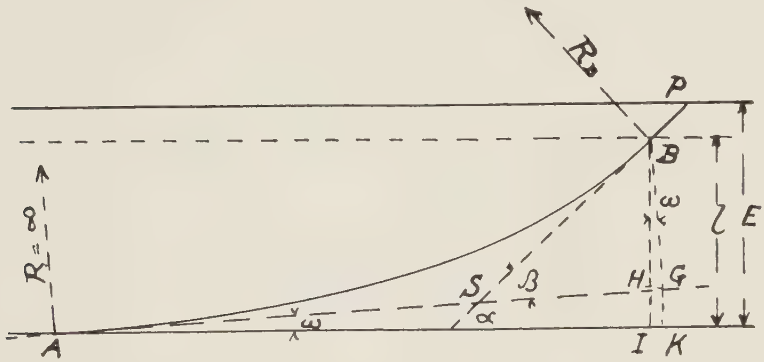

Fig. 15.

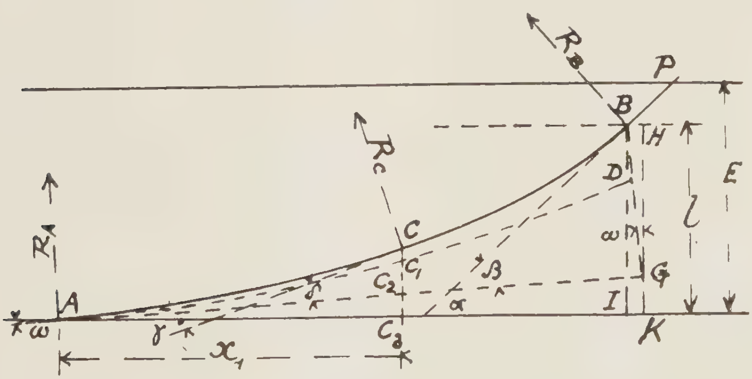

Fig. 16.

The turnout follows a curve of radius R, equal at the most, to the radius R_1 of the exit from the transition. At the same time the through road is no longer a straight line but a parabolic transition, having a curvature of $\frac{1}{R}$ at the switch toe, and $\frac{1}{R} - \frac{1}{R_1}$ at its extremity.

This alignment greatly simplifies the study of junction layouts in certain cases.

Superelevation.

Turnouts with parabolic transitions possess one unquestionable advantage over turnouts with circular branching-off roads, as regards providing the correct amount of superelevation with which the junction is to be laid. In turnouts with parabolic transitions, the superelevation can be applied progressively, as a function of the turnout curvature, whereas in turnouts with a circular branch track it cannot be other than constant throughout their length.

As a result of this, in the straight tracks at the switch toes A and C of the turnouts with circular branch curves, Fig. 1, the superelevation is as much as 8 or 9 cm. (3 1/8 to 3 1/2 in.) approximately, whereas it should be zero.

Although this may cause no serious inconvenience at the switch toe A of the turnout in the left-hand road, at the switch toe C of the turnout in the right-hand road the superelevation assists, as we have seen, the violent rebound of the vehicle on to the low rail, as the result of the change of direction imparted by the switch-angle.

In turnouts with parabolic transitions this drawback does not occur. Even though three or four centimetres (1 3/16 to 1 9/16 in.) of superelevation may be advisable at A, in order to mitigate the centrifugal acceleration due to the switch angle, the superelevation at C may be zero.

* * *

(2) High speeds in one direction only.

In cases where the directions MN and PQ are traversed at low speeds — 40 km. (25 miles) p. h. for example — and only the directions AK and CI are travelled at high speeds (Fig. 1), an excellent alignment for the junction is as follows : The sections of track HK and FI being laid as a rule on curves, the longest possible parabolic transition osculatory to the straight and the curve is introduced between each of these curves and the straight portions MN and PQ respectively.

The turnouts with circular branching-off curves AE, CF, and the diamond crossing GH are laid in such a way that their through roads lie in the transition curve [1], the switch toes A and C being at the commencement of each of the parabolic transitions.

The lead crossings and those of the diamond crossing (assuming various angles for the latter) are carefully chosen so that the branch roads of the turnout, and the opposite road of the diamond crossing afford an alignment suitable for a speed of, say, 40 km. (25 miles) p. h.

In existing tracks, a junction can be improved in this way when the turnout and the diamond crossing become due for renewal on account of wear. A ver-

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[1] « Courbes de chemins de fer, raccordements paraboliques (Etudes sans calcul intégral) » *(Railway Curves and Transitions* [without Calculus]), etc. Librairie de l'Enseignement technique, Eyrolles, publisher, Paris.

sines diagram of the alignment AEGH, or AFI, and the curve which follows on, enables a suitable parabolic transition, requiring the minimum slues, to be selected.

When the portions of track MA and PC may be curved, another solution consists in giving them the same radius as the branching-off roads AE, CF; or, in making them conform to the transition curve adopted. As in the previous case, the turnouts are laid so that their through roads follow the curvature of the branch, while the latter straightens out following an elongated sinusoid, or practically a straight line.

In existing tracks, either of the two solutions we have just described can sometimes be put into effect by mere slueing and partial re-screwing of the existing switches and crossings.

It can then be objected that the negotiation of the switch angles by the vehicles causes shocks, but tests have shown that at 110 km. p. h. a switch angle of 0° 51' 34'' (Fig. 13) situated in a curve of 2 000 m. (100 chains) radius, without superelevation, does not give rise to any perceptible variation of acceleration.

These two solutions enable the superelevation to be applied rationally, as in the case of turnouts with parabolic transitions.

Office work.

Alterations to the alignment of junctions in curved roads are drafted by means of plans drawn to a scale of 1 in 200.

In spite of the care taken in preparing such plans, setting out on the ground often reveals discrepancies. We are of the opinion that the following procedure is to be preferred :

Investigate the possible solutions on a 1 in 200 plan. Prepare the versines diagram of the curves in which the existing junction lies. Construct the versines diagram (1) of the new curves for the junction which has been drawn on the 1 in 200 plan. Calculate the slues required at each of the pegs of the existing curves, in order to bring them into the new alignment.

It will often be found that slues which ought to be zero have relatively important values. These slues are eliminated in the process of adjusting the versines of the new alignment, the versines of the through roads and the turnouts, and also of the diamond crossing thus having predetermined values.

Pegging out on the site is effected in a simple and precise way by moving the pegs of the existing alignment by the amounts indicated in the statement of slues.

* * *

Note 1.

Let ABP (Fig. 15) be the outer rail of a transitioned turnout curve, consisting of the parabolic transition AB, osculatory at A (point of tongue) with the straight section AG, the latter forming the switch angle ω with the rail AK; P is the theoretical intersection of the crossing of angle α, B is the extremity of the wing rail.

We propose to calculate :

Firstly, the length AI of the turnout, from the toe of switch tongue A to the extremity, B, of the wing-rail.

Secondly, the radius R_B of the osculatory circle at B of the parabolic transition AB.

(1) For calculation of these versines, see « Diagrams of versines and superelevations », *Bulletin of the International Railway Congress Association*, October 1930. « Raccordements paraboliques (Etude sans calcul intégral) ». Eyrolles, publisher, Paris.

Calculation of AI. — We have : $BH + GK = l$

$$BH = BG\cos\omega,\quad BG = SG\tan\beta,\quad SG = \frac{AG}{3},\qquad BG = \frac{AG\tan\beta}{3},\qquad BH = \frac{AG\tan\beta\cos\omega}{3},$$

$$GK = AG\sin\omega, \text{ whence } l = \frac{AG\tan\beta\cos\omega}{3} + AG\sin\omega, \text{ and : } AG = \frac{3\,l}{\tan\beta\cos\omega + 3\sin\omega},$$

$$AK = AG\cos\omega = \frac{3\,l\cos\omega}{\tan\beta\cos\omega + 3\sin\omega},$$

$$AI = AK - HG,\quad HG = BG\sin\omega =$$

$$\frac{AG\tan\beta\sin\omega}{3} = \frac{3\,l\tan\beta\sin\omega}{3(\tan\beta\cos\omega + 3\sin\omega)} = \frac{l\tan\beta\sin\omega}{\tan\beta\cos\omega + 3\sin\omega};$$

$$AI = \frac{3\,l\cos\omega - l\tan\beta\sin\omega}{\tan\beta\cos\omega + 3\sin\omega} = \frac{l\,(3\cos\omega - \tan\beta\sin\omega)}{\tan\beta\cos\omega + 3\sin\omega} =$$

$$= \frac{l\,(3 - \tan\beta\tan\omega)}{\tan\beta + 3\tan\omega} \approx \frac{3\,l}{\tan\beta + 3\tan\omega},$$

$l = E - PB\sin\alpha$; E : track gauge;

PB : Length depending on the design of the crossing.

Calculation of R_B. — The equation to the transition curve is :

$$y = \frac{x^3}{12\,p\,R_B}, \text{ consequently : —}$$

$$\tan\beta = \frac{dy}{dx} = \frac{x^2}{4\,p\,R_B} = \frac{AG^2}{2\,R_B \times AG} = \frac{AG}{2\,R_B},$$

$$R_B = \frac{AG}{2\tan\beta} = \frac{3\,l}{2\,(\tan\beta\cos\omega + 3\sin\omega)\tan\beta}$$

For $\omega = 0°\,45'\,0''$, $\alpha = 2°\,36'\,10''$, $E = 1.435$, $BP = 4.00$, we find : $R_B = 810$ m., $AI = 52.50$.

Note 2.

Let ABP (Fig. 16) be the outer rail of a turnout with parabolic transition, following the transition curve AB, osculatory at A (the switch toe) to a circle of radius R_A, and tangential at A with the straight line AG, the latter forming the switch-angle ω with the rail AK; P is the theoretical intersection point of the crossing angle α, B is the extremity of the wing-rail.

We propose to calculate :

Firstly, the length AG.

Secondly, the radius R_B of the osculating circle, at B, of the transition AB.

Thirdly, the ordinate of any point C on the transition curve AB, the angular coefficient of the tangent, and the radius of curvature, R_C, at that point.

Calculation of AG. — Let AD be the osculatory circle, at A, of the transition curve AB. Putting $AG = x$, we have (without appreciable error) : $BD = \frac{K\,x^3}{3\,a^3}$ [1], (K being the difference be-

(1) *Bulletin of the International Railway Congress Association*, October 1930. — Raccordements paraboliques (Etude sans calcul intégral). Eyrolles, publisher, Paris.

tween two successive versines of the versines diagram for the arc AB; a = the chord length between pegs) and

$$DG = \frac{x^2}{2 R_A}, \text{ whence } BG = \frac{K x^3}{3 a^3} + \frac{x^2}{2 R_A}.$$

Consequently the tangent at B to the transition curve, makes an angle β with the straight line AG, such that :

$$\tan \beta = \frac{dy}{dx} = \frac{K x^2}{a^3} + \frac{x}{R_A},$$

$$\text{whence } R_A K x^2 + x a^3 = a^3 R_A \tan \beta$$

$$\text{and } K = \frac{a^3 R_A \tan \beta - a^3 x}{x^2 R_A}$$

$$\text{and } BG = \frac{(a^3 R_A \tan \beta - a^3 x) x^3}{3 a^3 x^2 R_A} + \frac{x^2}{2 R_A} = \frac{2 x R_A \tan \beta + x^2}{6 R_A},$$

$$6 R_A \times BG = 2 x R_A \tan \beta + x^2,$$

$$x^2 + 2x R_A \tan \beta - 6 R_A \times BG = 0 \ (1).$$

On the other hand $l = HG + GK$, $HG = BG \cos \omega$, $GK = x \sin \omega$,

$$\text{whence } l = BG \cos \omega + x \sin \omega,$$

$$\text{and } BG = \frac{l - x \sin \omega}{\cos \omega};$$

$l = E - B P \sin \alpha$; E = track gauge; B P = length depending upon the design of the crossing (as given in the plan thereof).

Substituting for GB its value obtained in equation (1), we find :

$$x^2 + 2x R_A \tan \beta - \frac{6 R_A (l - x \sin \omega)}{\cos \omega} = 0,$$

or again :

$$x^2 + x (2 R_A \tan \beta + 6 R_A \tan \omega) - \frac{6 R_A l}{\cos \omega} = 0,$$

whence :

$$x = AG = - R_A (\tan \beta + 3 \tan \omega) + \sqrt{[R_A (\tan \beta + 3 \tan \omega)]^2 + \frac{6 R_A l}{\cos \omega}}; \quad \beta = \alpha - \omega$$

$$AI = AK - IK = AK - BH = AG \cos \omega - BG \sin \omega.$$

Calculation of R_B. — If we consider the curvature diagram for the transition arc AB, we have :

$$\frac{1}{R_B} = \frac{1}{R_A} + \frac{K}{\frac{a^2}{2}} \times \frac{x}{a} = \frac{1}{R_A} + \frac{2 K x}{a^3},$$

whence :

$$R_B = \frac{a^3 R_A}{a^3 + 2 K R_A x} = \frac{a^3 R_A}{a^3 + 2 K R_A \times AG}$$

Calculation of the ordinate CC_3 of the point C distant x_1 *from the origin.* —

We have :

$$y_c = C_2 C_1 + C C_1 = \frac{x_1^2}{2 R_A} + \frac{K x_1^3}{3 a^3},$$

$$C C_3 = y_c + C_2 C_3 = \frac{x_1^2}{2 R_A} + \frac{K x_1^3}{3 a^3} + x_1 \sin \omega.$$

Without serious error : $AC_3 = AC_2 = x_1$.

Calculation of γ. — We have :

$$\gamma = \delta + \omega.$$

From the equation, $y_c = \frac{x_1^2}{2 R_A} + \frac{K x_1^3}{3 a^3}$

we deduce that : $\tan \delta = \frac{dy}{dx} = \frac{x_1}{R_A} + \frac{K x_1^2}{a^3}$

Calculation of R_c. — By similar reasoning, we find :

$$R_c = \frac{a^3 R_A}{a^3 + 2 K R_A x_1}$$

For $R_A = 3\,000$, $\omega = 25'$, $\alpha = 2^\circ 36' 10''$, $E = 1.435$, $BP = 4.00$ we find :

$AG = 54.44$ m., $R_B = 935$ m.

We can determine all the dimensions of the transition curve AB in a different way.

We can produce this curve in the direction BA as far as the point O (not shown) where it is osculatory to a straight line (not shown) parallel to AK and below it.

In this way we obtain an ordinary parabolic transition, the curvature of which, at the origin, O, is zero, and $\frac{1}{R_A}$ at the point A.

The semi-overall length, p, of this transition is found to be given by the equation :

$$4 p^3 \tan \alpha - 6 p^2 l - \frac{(2 R_A \tan \omega)^3 \tan \alpha}{2} = 0.$$

By making use of the fact that $\tan \omega = \frac{x}{2 R_A}$ (where x is the distance between point A and point o), and that $\tan \alpha = \frac{p}{R_B}$, we are in a position to calculate all the dimensions of the transition curve AB.

[621.132.8 (.73) & 621.335 (.73)]

New American 5000-H.P. turbo-electric condensing locomotive for the Union Pacific Railroad,

by W. D. BEARCE,

Transportation Department, General Electric Company.

(*The Railway Gazette.*)

Nearly two years have been spent by General Electric and Union Pacific Railroad engineers in designing and building a 5 000-H.P. turbo-electric locomotive for handling fast and heavy passenger trains. This locomotive, which is now completed, is to be used on the fast and heavy express passenger services between Chicago and the Pacific Coast which have to negotiate 2.2 per cent. grades without a banking engine. Climatic conditions encountered *en route* range from — 40° F. in winter to 115° F. in summer. Some of the mountain passes through which the train must pass are over 8 000 ft. above sea level.

While the turbo-electric locomotive as a whole is still regarded by most engineers as experimental, the various pieces of apparatus out of which it is constructed have, for the most part, been thoroughly tried out and have demonstrated their reliability in other spheres. The assembly and arrangement of the equipment of this locomotive follow, in general, the practice in modern high-efficiency power plant work. Owing to the necessity for light weight and to limitations of space, some use has been made of experience gained in the installation of equipment on shipboard.

The boiler equipment differs from usual central station practice in the substitution of forced for natural circulation of the water through the tubes surrounding the furnace. The steam generated passes to a separator, where the excess water is removed by centrifugal action and then drained to the hot well. From the separator the steam goes through the superheaters and thence to the turbines. The exhaust steam goes to the condensers and the water returns to the hot well. The construction of this type of boiler precludes the possibility of any dangerous rupture due to any cause.

The electric motors, generators and control do not differ materially in design and construction from similar equipment supplied to trains now running. Briefly, then, the chief problem is the co-ordination of the several pieces of apparatus which go to make up the complete unit.

The operating advantages claimed for the steam-electric locomotive are as follow :

(*a*) Thermal efficiency from fuel to the driving wheels more than double that of the conventional steam locomotive.

(*b*) Electric braking resulting in saving in brake shoes and tyres, not only for the locomotive, but for the entire train.

(*c*) High rates of acceleration and braking due to high adhesive weight.

(*d*) Capacity for 500- to 700-mile performance without stops for fuel or water.

(*e*) Elimination of corrosion and boiler scale due to use of distilled water in a closed system.

(*f*) Elimination of unbalanced reciprocating parts which set up destructive forces in the rails, road bed, and supporting structures.

(*g*) Greater availability due to the construction of the boiler and absence of reciprocating parts.

Construction of mechanical portion.

The locomotive consists of two identical units capable of either multiple or independent operation under the control of one driver. Each unit consists of a 2-C-C-2 running gear surmounted by a single-ended streamlined cab.

The running gear of each unit consists of two three-axle driving trucks and two two-axle guiding trucks. The truck frames are integral nickel-vanadium steel castings. All wheels are of the solid type and all journals are in anti-friction bearings. The cab is mounted on centre plates, and the platform takes the buffing and pulling stresses. A flexible metal sleeve with sliding connection supplies ventilating air from centrifugal blowers located in the cab to each traction motor. The swivel truck arrangement provides room between the driving trucks for a well-type construction containing the steam boiler in the central part of the cab.

To secure smooth running at high speeds, restraint devices are used between the main trucks and cab, and between guiding trucks and main trucks. Side bearing pads on each main truck give the cab additional support.

The cab is designed to secure the lightest possible construction consistent with the requirements of strength and rigidity. The frame is built up with high-tensile steel tubular members, and aluminium cab sheets are employed except for the streamlined nose, which is of steel welded throughout. In the fabrication of the cab, welding is largely used, except for the aluminium sheets, which are riveted in place.

The locomotive is designed for single-end operation, with streamlining to minimise wind resistance. The front coupler is normally retracted and covered by a removable panel which conforms to the streamlined contour of the pilot structure.

Clasp brakes are used on both driving and idle wheels with four shoes per wheel on the drivers. The braking on these drivers is supplied from two cylinders per axle. A new high-speed air brake equipment suitable for use with both new and conventional trains has been included.

To facilitate maintenance, provision is made for replacing any unit of the power plant or electrical equipment, including the main boiler, in a few hours. Traction motors may be removed in a drop-pit. Other equipment can be removed by a crane through the roof.

Each cab encloses the following principal elements : a complete 2 500-H.P. geared turbine-driven generator set; a high pressure steam boiler; a compactly built turbine-driven auxiliary set with full automatic control; and a finned tube air-cooled condenser with turbine-driven fans for cooling.

The design of this locomotive is unusual in many respects, some of which are :

(*a*) The use of 1 500-lb. per sq. in., 920° F. steam.

(*b*) A type of boiler not previously used for railway service.

(*c*) Complete automatic control of boiler, auxiliaries, and power units.

(*d*) Provision for electric braking of sufficient capacity for holding trains on grades and for assistance in making service stops.

(*e*) Head-end auxiliary power for air-conditioning and other train electric service.

Many other features are incorporated in the design for the purpose of effect-

ing economies in operation, simplifying the duties of the operator, lengthening the cruising radius, and reducing maintenance cost.

This new Union Pacific locomotive is particularly adapted to lines where full electrification is not justified, but where superior passenger schedules are demanded. Each unit of this locomotive has the following ratings, weights, and dimensions :

Wheel arrangement per unit	2-C-C-2
Total weight (in British tonnage) with full tanks of fuel and water. . . .	236 tons 12 cwt.
Weight on driving wheels.	152 tons 13 cwt.
Weight per driving axle .	25 tons 9 cwt.
Fuel oil capacity	2 500 gall. (Imp.)
Water capacity.	3 330 gall. (Imp.)
Total length over couplers.	90 ft. 10 in.
Overall width	10 ft. 8 3/4 in.
Maximum height	15 ft. 0 3/4 in.
Maximum rigid wheel base	13 ft. 4 in.
Diameter of driving wheels	3 ft. 8 in.
Diameter of guiding wheels	3 ft. 0 in.
Rating of main turbines .	2 500 H.P.
Number and type of traction motors	6-GE-725
Gear ratio 65/31	2.097
Maximum operating speed.	125 m.p.h.

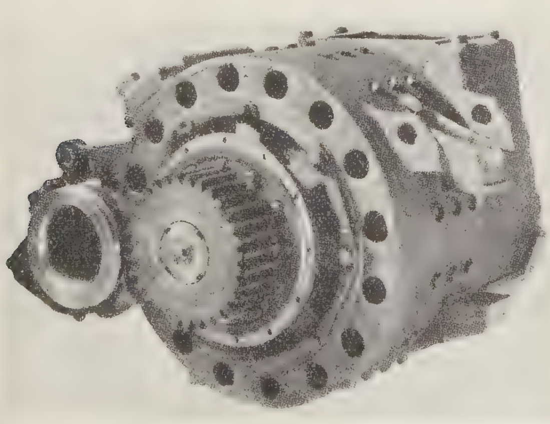
In order to obtain the capacity, flexibility, and efficiency essential to the best train operating characteristics, the power equipment has been designed to respond promptly to sudden demands for power. The rate of firing therefore increases and decreases automatically with the load demand.

Steam boiler.

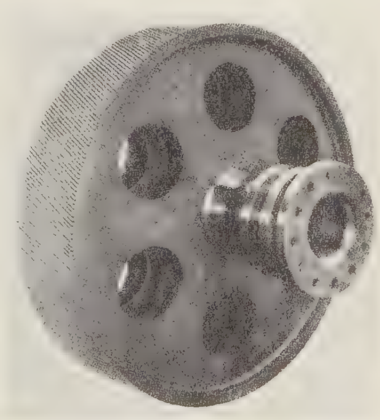
The steam boiler and automatic control equipment were designed and built by Babcock & Wilcox and the Bailey Meter Company, builders of boilers and steam control, in collaboration with General Electric. The boiler is a water-tube forced-circulation type, compactly built, incorporating a furnace, super-heater, economiser, air pre-heater, and burners for Bunker C fuel oil. Special provisions are made to withstand shock and vibration resulting from the movement of the vehicle over the rails.

By replenishing water losses in the closed system with evaporator steam, practically all scaling and corrosion of the tubes are eliminated. The construction of the boiler unit and its 3-point supports furthermore avoids distortion of the tubes due to normal movement of the locomotive.

The economiser is an integral part of the boiler and utilises waste heat for increasing the temperature of the boiler feed water. Several boilers of this type have been built by Babcock & Wilcox

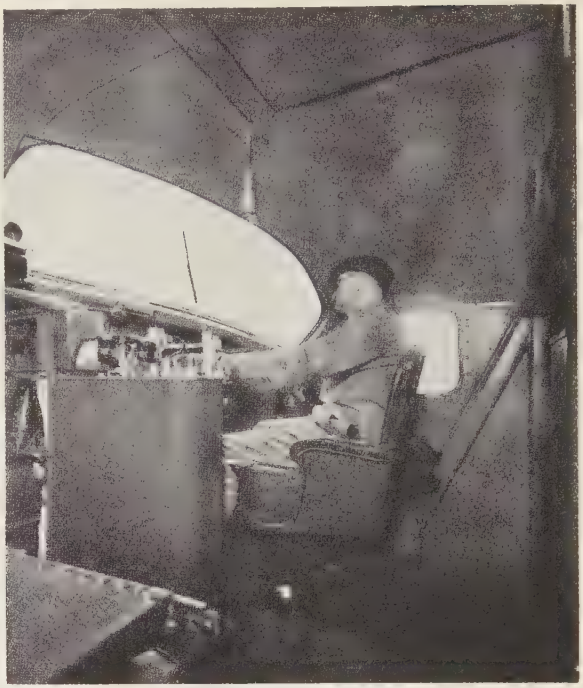


Nose-suspended d.c. traction motor.



Low-speed gear for main unit of locomotive.

View in cab showing train control fittings.



Driver's compartment.

and are successfully handling commercial service in stationary plants.

For starting the locomotive when cold a small vertical fire-tube boiler with a capacity of 100 lb. of steam per hr. is provided, using propane gas for fuel. This boiler supplies steam for heating the fuel oil and atomising the oil at the burners when starting the main boiler. The auxiliary boiler is designed for a pressure of 75 lb. per sq. in., and is used only for starting when an outside supply of steam is not available. Where steam can be secured at a roundhouse or from an external source the main boiler can be started without the use of this auxiliary.

Main turbine and auxiliaries.

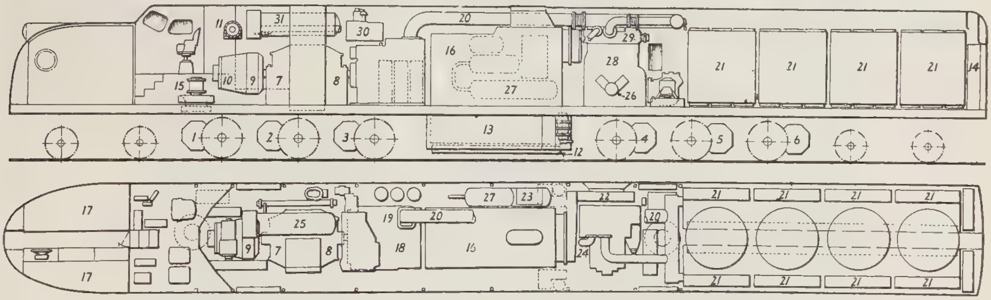
The main turbine generator set consists of the following elements :

(*a*) High- and low-pressure turbines.

(*b*) A two-armature direct-current generator driven through a gear reduction approximating 10 to 1 from these turbines. This generator is self-ventilated from a fan located between the armatures, the air being drawn in through the commutator risers and discharged at the centre through the roof of the locomotive. In cold weather this warm air can be utilised for cab heating.

(*c*) A 220-volt 3-phase alternating-current generator connected to the main generator shaft through a flexible disc coupling. This alternator furnishes power for train air-conditioning, traction motor blowers, and other accessories.

(*d*) A variable voltage exciter, the armature of which is mounted on the same shaft as the alternator. This ma-



1-6 Traction motors.
7-8 Main generators.
9 Alternators.
10 Exciter:
11 Battery charging set.
12 Braking resistor.
13 Main control contactors.
14 Battery.
15 Traction motor blower.
16 Boiler.
17 Raw water tank.
18 High-pressure main turbine.
19 Low-pressure main turbine.
20 Exhaust header.
21 Air-cooled condensers.
22 Boiler draught fan.
23 High-level condensate tank.
24 Braking resistor separator.
25 Train heating evaporator.
26 Feed-water pump.
27 Feed-water heater.
28 Boiler auxiliary set turbine.
29 Condenser fan turbine.
30 Compressor.

chine supplies excitation for the main generator during motoring, and for the traction motors during electric braking.

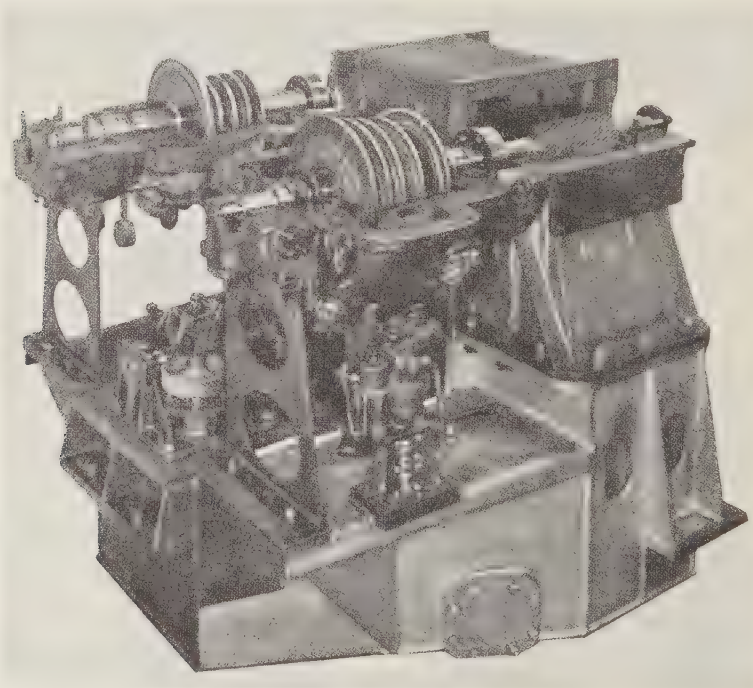
The auxiliary set is a variable-speed unit driven by a turbine which takes steam extracted from the main turbine. Its speed therefore varies somewhat with the traction load on the main turbine. This speed is further controlled automatically in accordance with the steam demand from the main boiler. Its function is to supply and regulate the combustion air and fuel oil delivered to the furnace, and also to supply feed water in proportion to the demand for steam. The complete set consists of a starting motor, an auxiliary turbine, combustion air fan, boiler feed pump, and fuel oil pump.

The lubricating pump for the auxiliary set is of the rotary-type, independently driven by a direct-connected 125-volt

direct-current motor. This pump is used for circulating lubricating oil to the reduction gearing, gear shaft bearings, turbine bearings, and feed water pump bearings. The circulating oil is cooled by radiators located with the condenser units. The condenser fan turbine is also independent of the auxiliary set drive, but is mounted on the same support. This turbine operates at a variable speed which is dependent on the condensation requirements but has a maximum speed of about 12 000 r.p.m. The condenser is mounted on each side of the rear end of the locomotive cab, and consists of finned-type vertical tubes. Headers at the top receive the exhaust steam from which the condensate is drained by gravity to a sump-tank under the locomotive cab. Ventilation for the condenser is provided by turbine-driven propeller-type fans drawing air through the sides of the locomotive and discharging it through openings in the roof.

As a part of the condenser equipment there is a steam-operated vacuum ejector for extracting small quantities of air which may leak into the closed system. This ejector normally will function under partial vacuum conditions down to 5 lb. per sq. in. absolute.

In normal operation the condensed water in the tank under the locomotive cab is maintained at a constant level by a float switch. Provision is also made for the addition of make-up water as required. Water from this tank is pumped into another tank located high in the cab, using a centrifugal type pump. In normal operation the upper tank will be kept full, the excess water overflowing and returning to the lower tank. An-

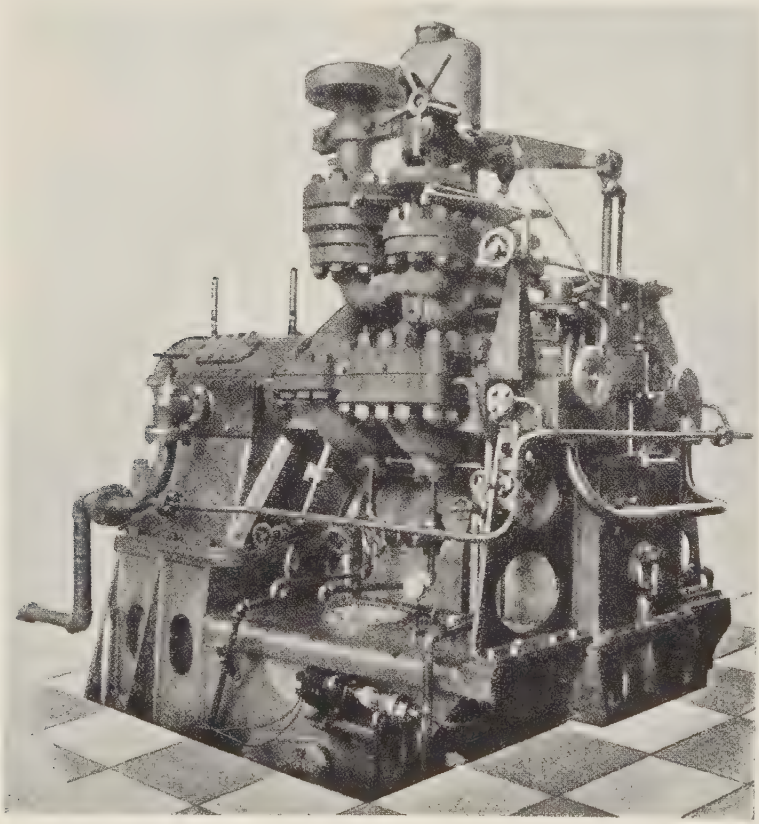


Steam turbine and gear with casing top removed.

other pump transfers the water from the upper tank to the suction side of the feed water pump. From this point the water passes through the feed water heater, the economiser, thence to the boiler tubes and then to a separator drum, from which excess water is returned to the sump. The steam passes through the superheater and turbines and back to the condensers.

A continuous supply of low-pressure steam is required for train heating, the operation of the air compressor turbine, and for heating fuel oil. For this purpose a heat exchanger or evaporator is used, consisting of a coil immersed in raw water. This coil takes steam either direct from the main boiler or by extraction from the main turbine. In either case the pressure is reduced before entering the coil. Water is supplied to the evaporator by three reciprocating pumps driven by direct-current motors.

A 150-cu. ft. double-stage air compressor designed to supply 125-lb. to 135-lb. pressure is driven by a steam turbine operating at 200-lb. pressure and driving through a reduction gear. This compressor set is regulated by a governor which operates a shut-off valve in the turbine supply, starting and stopping the set as required. A 15-cu. ft. compressor sup-



Oblique side view of complete unit.

plying air at 90-lb. pressure and operated by a 125-volt direct-current motor is provided for supplying air for operating the Bailey regulating devices and control equipment during starting when no steam is available for operating the turbine compressor set.

Electrical circuits.

This type of locomotive is essentially an electric locomotive carrying its own power plant. Since the main generator, however, is used solely for furnishing power to the traction motors, advantage is taken of the opportunity to regulate the train speed by varying the generator voltage, thus avoiding rheostatic losses. Acceleration of the train, therefore, is effected by controlling the current in the exciter field by means of the master controller, thus regulating the field current in the main generators. The main generator current is thus supplied to the axle-hung, geared traction motors at varying voltages, depending upon the demand for power and speed. Control current is supplied by a 125-volt motor-generator set with a battery floating on the line. Both acceleration and electric braking are regulated indirectly through the master controller.

This master controller includes an accelerating handle, an electric braking handle and a reverse handle. The reverse handle is also used as a selector handle for motor combinations in each direction. Provision is made for operating the motors in three combinations — series, series-parallel and parallel. Both the accelerating and braking handles normally hold a fixed kilowatt load on each controller step, except during the first few motoring steps, where approximately constant tractive effort increments are obtained.

The primary power for the auxiliaries is supplied by the a. c. generator. In addition to the operation of the two traction motor blowers this unit also supplies the motor-generator sets, supplying 125 and 64 volts d. c. Lighting circuits and headlights are also supplied from this a. c. source. Plug receptacles on the exciter of the locomotive at both sides permit obtaining alternating-current power from an outside supply. The 64-volt motor-generator set supplies power for the standard train circuits.

Automatic control features.

The power plant is entirely automatic in operation and there are no power plant pressure or temperature gauges in the operating cab. These devices are located on a control board situated in the apparatus cab. In the event of the operation of any of the protective devices, a warning gong rings in the apparatus cab and an indicating lamp shows at the driver's position.

Automatic train control and cab signal equipment of the continuous type with suitable inductors for operation over Union Pacific lines are installed on both units.

The mechanical and electrical parts of this locomotive were manufactured in the Erie plant of the General Electric Company, the boiler was supplied by the Barberton plant of the Babcock & Wilcox Company, and the boiler control devices by the Bailey Meter Company, of Cleveland. The locomotive is now undergoing tests, upon completion of which it will be placed in regular service by the Union Pacific Railroad.

Acoustic methods of sounding concrete and metal structures.

(From *Le Génie Civil.*)

Sounding large structures is a process of long standing which the engineer Rabut brought into common use when he developed the Manet-Rabut apparatus (which has been in general use some forty years) and applied it to the direct measurement of stresses produced by loads in motion on steel bridges on the French railways (1).

These measurements were of all the more value in that they showed that, owing to hyperstatic interactions which the designers had not allowed for in their calculations, these bridges were capable of carrying, either in their original condition or after judicious strengthening, the increased stresses due to the heavier and faster trains which were running over them. In this way the Railways avoided a considerable amount of very expensive reconstruction work.

The Manet-Rabut apparatus, now standard, are very good indeed, but require direct-reading, a fact which complicates and retards the measurements, especially in the case of large structures in which certain portions are not easy of access. In addition, these measurements only indicate deformations taking place during the short period covered by the test, since the apparatus cannot be left in place for a lengthy period without being thrown out of adjustment and otherwise damaged.

(1) M. Rabut published his « Recherches expérimentales sur la déformation des ponts métalliques » (Experimental investigations into the deformations of metal bridges), in the *Génie Civil* in 1892, 1893 and 1894.

For some appreciable time consideration has been given to the design of apparatus making possible remote readings, and permanently installed without risk of getting out of order. There are various ways of effecting this, for theoretically each of the physical reactions produced by stresses in the medium under observation, or in the measuring apparatus attached to it, affords a means of solving the problem. For instance, a variation in stress can cause a variation in temperature or magnetic flux in some thermo-elastic or magneto-elastic apparatus; variations in pressure on a carbon cell or the junction of a bimetallic cell may produce a change in resistivity capable of measurement by instruments traversed by current flowing through the carbon or metal cell, etc.

Another variety of this type of apparatus is based on acoustics, and it is to this kind that Mr. Coyne, Chief Engineer for Roads and Bridges, has particularly devoted his attention since 1925 (1). With the co-operation of his colleagues and of well-known manufacturers he has evolved a method of applying this process, and he has expounded all the aspects of the question, which is of obvious importance, in a communication to the « Centre d'Etudes de l'Institut technique du Bâtiment et des Travaux publics ». We shall give a resumé of this, taken from the *Annales de l'Institut technique du Bâtiment,* which published

(1) An account of Mr. Coyne's work in this sphere had already appeared in the *Génie Civil* for the 27th February, 1932, p. 225.

the description in its issue for July-August, 1938.

Principles of acoustic sounding.

A vibrating wire with its two ends attached to the object under observation is affected by its deformation, and hence its frequency of vibration varies with the expansions and contractions undergone by that object.

The wire is remotely excited by an electro-magnet in which flows a weak current (produced, say, by a small condenser) and the vibrations are detected on the same circuit by means of a valve amplifier at a central listening-in point.

At this central measuring point the frequency of the sound emitted by the wire has to be determined. To do this it is only necessary to compare it by means of the acoustic beats with the frequency of a standard wire (made of steel, as is the sounding wire) under the control of the operator, the tension of which he may vary at will. When the two wires are in unison, their tensions are equal, if they are of the same length, and proportional if they are of different lengths (1).

This is actually a matter of measuring tensions, or, rather, differences in tension between two successive conditions of the wire. As a matter of fact, it is unnecessary to know the zero position. All that is necessary is to measure the tension T for an initial condition and the tension T' for a new condition : the difference T' — T gives the stress during the interval. A positive reading indicates a tensile force, and a negative one a compressive force.

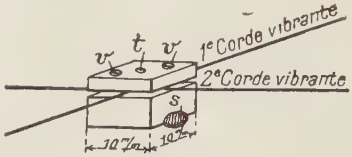


Fig. 1. — Method of securing acoustic wires to a metal part.

s, lower clamp block secured to surface by welding. — *t*, hole through both clamp blocks to facilitate crossing of the wires. — *v*, clamping screw for top block.

Note. — Corde vibrante = vibrating wire.

To calibrate the instruments at the observation post one or more controlling tuning forks enable the frequency of the standard wire to be compared with a known fixed frequency, so as to provide a method of zero correction, if such is necessary, at the moment of taking readings.

Such apparatus is extremely sensitive. In the laboratory it enables a variation in length of one micron per metre to be detected. Of course the sensitiveness is not so great in the field, where there are a number of adverse factors which reduce the accuracy of measurement to about 2 or 3 microns per metre, a figure which represents a stress of approximately 50 gr./mm² (71 lb./sq. in.) in steel and 0.5 kgr./cm² (7 lb./sq. in.) in concrete.

Method of construction.

When measurements have to be taken on steel parts the vibrating wire is gripped in screw clamps electrically welded to the part to be sounded. If the sounding affects a certain length, the number of fastening points of the wire is increased by spacing them about

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(1) The formula for vibrating wires is :

$$N = K \frac{\sqrt{T}}{L}$$

where T = tension; L = length; K = coefficient depending on the specific weight of the wire.

Let : $N = K \frac{\sqrt{T}}{L}$ and $N' = K \frac{\sqrt{T}}{L'}$ be the frequencies of the two wires. If N = N', we have :

$$\frac{\sqrt{T}}{L} = \frac{\sqrt{T'}}{L'} \text{ or } \frac{T}{T'} = \frac{L^2}{L'^2}.$$

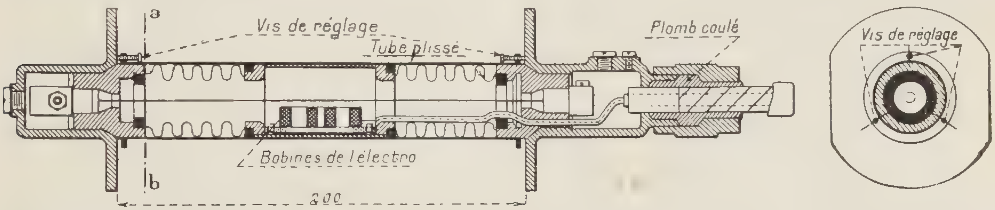
20 cm. (8 in.) apart. If a wide surface is to be observed several wires are used in the form of a squared network.

In the case of a concrete mass the wire is enclosed in a sealed tube embedded in the concrete, and the apparatus forms an « acoustic detector » (figs. 2 and 3) which permanently shows the conditions as regards tension or compression of the surrounding medium.

sound heard in the listening-in set is exactly the same as that generated by the detector.

An accurate preliminary calibration is not necessary, and even if the acoustic detector is somewhat mishandled while it is being placed in the concrete, the initial sound will alter, but will not affect the ultimate accuracy of the measurements.

The only possible errors are those



Section through *ab*.

Figs. 2 and 3. — Sections through acoustic detector for observations on concrete.

Explanation of French terms :

Vis de réglage = adjusting screw — Tube plissé = corrugated tube. — Bobines de l'électro = Magnet coils. Plomb coulé = lead seal.

The standard wire itself is stretched along the centre line of a steel tube : its tension is adjusted by a micrometer screw, and the instrument is termed a « frequency-meter ».

The listening-in set allows of the successive or simultaneous hearing of the acoustic detectors, the frequency-meter and the controlling tuning forks.

The advantage of acoustic apparatus as compared with the electric type, which soon becomes inaccurate, as has been shown by experience with large dams in the U. S. A., is primarily its simplicity, but especially the fact that it operates on the principle of *frequency measurement*. Dampness, bad contacts and defective insulation, which badly upset the working of electrical apparatus, have no effect on frequency. If the wire emits a sound and the electrical circuit is not open, the pitch of this

from thermal causes, if the apparatus and its support, although in thermal equilibrium, do not possess the same coefficient of expansion (case of an acoustic detector embedded in the concrete) : — When the temperature rises, the wire in the detector slackens, since it lengthens more rapidly than its sup-

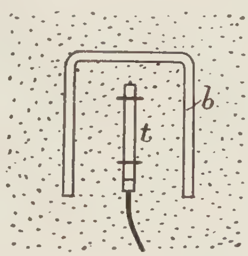


Fig. 4. — Arrangement of detector for temperature correction.

b, double-walled box. — *t*, detector shielded from surrounding stresses.

port, and the pitch of the sound drops : conversely, when cooled, the wire tightens and the pitch rises.

The simplest method of overcoming this source of error is to isolate one detector from the zone of stresses by enclosing it in a double-walled box (fig. 4); readings taken from it will show the error due to temperature differences, since it is only influenced by the latter; the error is then deducted from the readings obtained from the other detectors, so as to measure only the actual stresses to which the latter are subjected.

Laboratory tests.

Accoustic sounding may be employed in the laboratory in all cases where the parts to be examined are sufficiently large to allow of vibrating wires of 5 cm. (2 in.) minimum effective length to be fitted externally or internally. The sphere of application of the acoustic method is therefore very wide, especially when it is desired to observe deformations over a considerable period of time, and Mr. COYNE gives a detailed description of a series of tests he carried out at the Bridges and Highways Laboratory to demonstrate its usefulness.

We shall confine our remarks to a mention of the object of the tests : — determination of stresses existing in a mass of concrete; measurement of the contraction in a concrete beam, and of the elastic modulus of the concrete; action of the stirrups in ferro-concrete; measurement of the coefficient of expansion of concrete; gradual deformation (measured over a period of five years) of a reinforced concrete beam subjected to normal loads. This latter test shows up the lasting accuracy of the acoustic detectors when used in tests of long duration.

Applications to structures such as dams, quay walls, and penstocks.

Mr. COYNE then quotes a number of field tests, which show the ease with which the method may be applied in each case.

For instance, the measurement of the tensile stresses in ties supporting a quay wall constructed of metal sheet piles, at Havre, has made clear a number of facts which the author recounts; similar results were obtained in the case of the reinforced concrete ties of a quay wall at Dieppe (the acoustic detectors were placed in these ties during the placing of the concrete).

A particularly interesting example is the sounding of the dam on the Bromme, constructed in 1931 by the « Société des Forces motrices de la Truyère », and described in the *Génie Civil* of the 17th September, 1932.

In this arch dam, 40 m. (131 ft.) high, about twenty detectors were located in the contraction joints, and at the time of putting under load it was possible to obtain by this means a considerable amount of information of which Mr. COYNE points out the practical value.

Later on, the same process was applied on a much more extensive scale to the Marèges dam on the Dordogne, which was described in the *Génie Civil* for 26th October, 1935. About eighty detectors were located in this huge mass 90 m. (295 ft.) high, the majority being parallel to the outside facing and about 1.50 m. (4 ft. 11 in.) from it.

They are for the most part arranged in groups of three, forming an equilateral triangle with the base horizontal. This arrangement enables the directions of the principal stresses to be determined at each point under observation.

A certain number of these groups have a fourth detector in addition, which is relieved of all stress by locating it in a double-walled box, which allows a temperature correction to be made as described above.

By this means the deformations of the dam have been periodically observed

since the filling of the reservoir in June, 1935. These observations furnish most valuable information concerning the distribution of stresses in the structure, and it has been most satisfactory to detect each year the reappearance of the same stresses for the same conditions of loading and temperature.

Acoustic detectors have also been employed to control the hooping of the penstocks at the Marèges generating station. These are underground conduits of 4.40 m. (14 ft. 3 1/4 in.) internal diameter, made of concrete banded on the outside with cables of 70 mm. (2 3/4 in.) diameter.

Since the internal hydraulic pressure exceeds 100 kgr./cm^2 (1 422 lb./sq. in.) the cables, which form rings spaced 0.50 m. (19 11/16 in.) apart along the penstocks, were tightened up under a load of 135 tons so that the concrete conduit was subjected to an initial compression of more than 80 kgr./cm^2 (1 137 lb./sq. in.), and is thus capabe of standing up to the internal water pressure without difficulty.

To obtain the maximum degree of safety from this arrangement, the compression of the concrete must be kept under control, and the tension in the cables which maintain this compression must be watched continuously.

It has been found by means of the detectors that the sphere of action of one cable extends for more than 1 m. (3 ft. 3 3/8 in.) on either side, so that the concrete is maintained in a very uniform state of compression.

Lastly, acoustic detectors have been used at Marèges for keeping under observation the points of divergence of two metal penstocks feeding two secondary generator sets.

Finally, as an example of acoustic detection applied to bridges — either of metal or reinforced concrete construction — Mr. COYNE mentions the sounding of the Port-de-Pascau bridge, over the Garonne, in the Lot-et-Garonne Department. This is a three-span metal bridge with continuous lattice girders supporting a floor of reinforced concrete. In this case also acoustic detectors have enabled a study to be made of the stresses in the different members forming the lattice, and the part played by the reinforced concrete floor in relation to the main girders.

New applications of the method.

Apart from the cases just mentioned, acoustic detection may be employed for numerous measurements in the domain of physics, and Mr. COYNE examines two varieties of these : dynamic measurements and the measurement of subsoil pressures.

Dynamic measurements.

If the stresses vary on a time basis, it is only necessary to record the vibrations of the detector wire on a film by means of an oscillograph : the analysis of the record, which may be made afterwards at leisure, enables the curve of frequency variation — hence of stress variation — to be drawn to a time basis.

In practice, counting the oscillations recorded on the film is apt to be a lengthy and tedious process and hence may give rise to errors. When the stresses are not varying very rapidly, there is an easy method of simplifying this counting : it is only necessary for the oscillograph to receive simultaneously the current of varying frequency coming from the wire under observation and the current coming from a standard wire previously adjusted to a fixed frequency slightly different from the former.

In this way a record is made of the beats, which are themselves of varying frequency, and to obtain the required graph it is sufficient merely to count up the beats, which are far fewer than the primary vibrations.

This method has been employed on the metal penstocks of the Marèges gen-

erating station during one of the water-hammer acceptance tests made of the turbines. The turbine blades were closed in four seconds; their automatic closing was caused by the sudden interruption of the alternator electric circuit through the liquid resistance.

Measurement of subsoil pressures.

Exact knowledge of pressures existing in various subsoils is of outstanding importance to the engineer. A special arrangement of acoustic wires has been evolved for their measurement; it consists essentially of a diaphragm box comprising a rigid container closed at one end by a circular plate securely held all round its circumference. At each end of one diameter, the plate carries two lever arms, and between the ends of these the wire is stretched.

When the box is buried in the ground the plate is subjected to bending and the resulting angular displacements vary the tension in the wire. A noteworthy characteristic of the apparatus is that a deflection of a few microns at the most in the centre of the plate is all that is necessary to obtain adequate sensitivity for reading off purposes.

The same arrangement has been used to measure pressures exerted inside the mass of grain in a grain elevator bin, in proportion to the height of the mass of grain above the diaphragm.

Conclusions.

Mr. COYNE ends his account with the following summary of the advantages and scope of acoustic sounding :

Whether a laboratory analysis has to be made of little known phenomena, such as the contraction and gradual deformation of concrete, or wall effects, or if we have to verify the truth of rules used in construction; if in the structures themselves or in the subsoil we have to compare the calculated with the actual stresses — and when there is a discrepancy, as frequently happens — we have to amend theory in order to do better at less cost; if we have to observe the effects on structures of methods of force co-ordination, or to exercise instantaneous or continuous control over large structures, especially those most liable to failure, such as dams; finally, if we have to ascertain in due time, earth movements, especially the slow movements which cause the greatest mischief with structural work; then, the apparatus which you have before you will enable us to solve all these problems.

Nevertheless, many engineers hesitate to make use of it. Some object on grounds of expenditure. I have difficulty in believing that the few thousand francs required for a reasonable amount of observation work are of any account in comparison with the advantages of every description to be gained by a more exact knowledge of the stresses in the material, a knowledge from which we may gain a twofold benefit : safety and cheapness of construction.

Others object on grounds of time. It is true that the amount of time we can devote to scientific research is growing less and less. But the remedy is simple : there are specialised organisations capable of undertaking such observations and drawing conclusions from them.

Lastly, there is a third stumbling block. Some engineers are quite in the wrong as to what may be expected from this sounding method. They look for confirmation of their views. They would like the conclusions of theory, however outworn, never to be discredited. Actually, the reverse is the case. Measurements made with standard extensometers as well as with acoustic detectors are full of unforeseen results; and if it sometimes happens that the unforeseen result appears to arise from an error in measurement, in the majority of cases, it is mostly the measurement which is right and the theory which is wrong, because some consideration or other has not been taken into account in the assumptions made.

[625. 143.4 (.73) & 665. 882 (.73)]

New oxy-acetylene process for butt-welding rails.

(Railway Engineering and Maintenance.)

When the New Haven butt-welded rails into 800-ft. lengths for installation in four main tracks through its station area at Hartford, Conn., it utilized a new oxy-acetylene method in which, using special equipment, the abutting rail ends are brought together and heat and pressure are applied simultaneously until the weld is completed. Essential features of the new welding procedure and of the incidental operations involved and the equipment employed are described in this article.

General view of the welding operations showing (right to left) the welding machine, the oxy-acetylene cutting machine, and the annealing unit, to the left of which are the flat cars for storing the welded rails.

Utilizing a newly-developed oxy-acetylene method of butt-welding rails into continuous lengths, the New York, New Haven & Hartford recently installed eight lines of such rails, averaging 800 ft. in length, in the four main tracks through its passenger station area at Hartford, Conn. At this point, where the tracks are carried through the station area on a structural-steel viaduct, moving trains formerly occasioned considerable noise in the vicinity of the station, particularly in a passenger subway under the tracks, and it was largely for the purpose of reducing this noise that the continuous rails were installed. For this installation 112-lb. A.R.E.A. section rails were used, which were butt-welded into four lines having twenty-one 39-ft. rails each, and four lines having twenty-three 34-ft. rails each.

Essentials of process.

The welding procedure employed was developed and perfected by The Oxweld Railroad Service Company, a unit of Union Carbide and Carbon Corporation, and is known as the Oxweld automatic pressure rail-welding process. Using specially-designed equipment, this process involves essentially the uniform

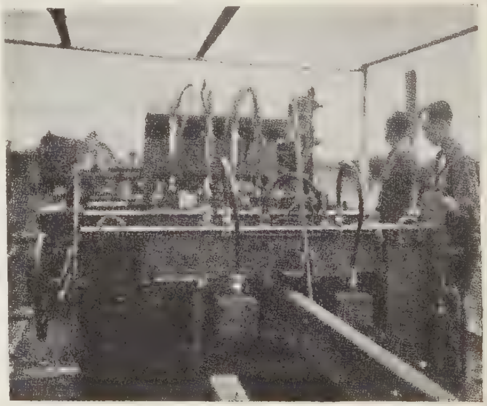
Three stages of a butt-welded joint. Left — As it comes from the welding machine. Center — After part of the upset metal has been removed by the cutting blowpipes. Right — After the finish grinding has been completed.

heating of abutting rail ends to a temperature of about 2 280 deg. F., utilizing a mechanically-oscillated welding head that applies heat evenly to the rail sections from all directions. Simultaneously with the application of heat, the rail ends are forced together under a pressure which attains a maximum of 2 500 lb. per sq. in. Under these conditions, the rails are brought together in an upsetting action that involves shortening each rail 3/8 in. or each weld 3/4 in.

Another important phase of the procedure is the « normalizing » or stress-relieving operation to which the welds are subjected. In this process, the purpose of which is to achieve a refinement of the grain of the metal in the vicinity of the joint and to relieve internal stresses set up during the welding procedure, the joint is uniformly reheated to the critical temperature (about 1 380 deg. F.) and allowed to cool in the atmosphere. In this operation, the reheating of the joint is done with welding heads that are similar in design and arrangement to those used in the welding process.

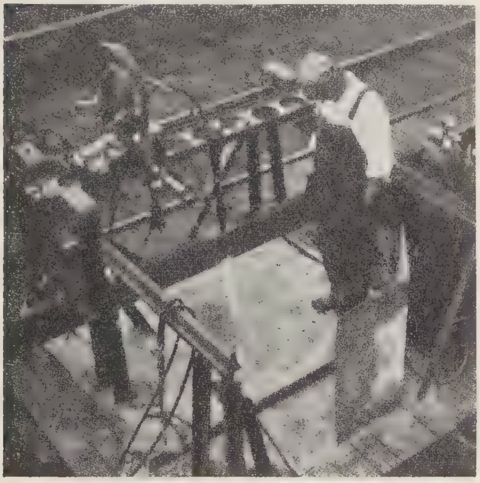
Physical properties of welds.

To determine the physical properties of butt-welds made by this method, extensive laboratory tests have been conducted with specimens taken from welds made in 112-lb. rail. Representative results of these tests show that the metal at the butt-weld has a yield strength of 70 000 lb. per sq. in. and a tensile strength of 135 000 lb. per sq. in. with an elongation of 9 per cent. Tensile impact tests with specimens 0.236 in. in diameter show an elongation of 9.5 per cent under a load of 107 ft.-lb. In one series of tests it was reported that of a total of 20 specimens tested, 19 broke at points other than at the weld. In a rol-



The welding machine as seen from the receiving end.

ling-load fatigue test involving a welded rail supported as a cantilever, a load of 50 000 lb. was rolled back and forth across the joint through 2 000 000 cycles, and when failure did not occur at the end of this period the test was discontinued.



Removing upset metal from a newly-welded joint with the oxy-acetylene cutting machine.

In addition to the welding and normalizing operations, other steps in the butt-welding procedure include the grinding of the ends of the rail to a high degree of accuracy and cleanliness prior to the welding operation; removal of part of the upset metal by using a machine-guided oxy-acetylene cutting blowpipe; and the finishing of the joints by grinding. These and the welding and normalizing operations are performed in the following order : (1) Facing the rail ends; (2) making the butt weld; (3) removing the upset metal; (4) normalizing the weld; and (5) grinding the joint.

In the butt-welding work on the New Haven, all operations were performed on a string of flat cars of sufficient length to accommodate the equipment and the finished lines of rails, these cars being spotted on a conveniently situated yard track at Hartford. The layout involved the use of an adjacent track, from which the rails were transferred from cars to a rack car at the receiving end of the welding line. After the faces of the rails were ground, the rails were barred from the rack onto a conveyor line, consisting of rollers spaced at convenient intervals, by means of which they were conducted through the various operations of welding, cutting and heat treating.

Arrangement of equipment.

Equipment employed in the welding process included the welding machine, situated near the receiving end of the first car beyond the rack car; the oxy-acetylene cutting apparatus for removing the upset metal, which was placed a rail length away near the leaving end of the same car; and the normalizing unit which was located a rail length from the cutting operation near the center of the third or following car. All grinding work, including the facing of

In the normalizing operation the welds are reheated to the critical temperature (about 1 380° F.) and are then allowed to cool in the atmosphere.

the rail ends, was done with portable, power-operated grinding equipment at suitable locations on the cars.

Welding machine.

The essential features of the welding machine, which is mounted in a heavy frame of structural members, are the welding or heating heads, which are

Each length of rail was laid by pulling the string of cars from beneath it.

placed near the longitudinal center of the frame; the necessary parts for gripping the trailing end of the leaving rail and the forward end of the incoming rail; hydraulic equipment for applying the desired longitudinal pressure at the juncture of the two rails; and the necessary control devices. A heavy roller at each end of the frame facilitates the movement of the rails through the machine.

Equipment for holding the rails and applying the pressure includes two sets of grippers. The grippers at the forward end of the machine are stationary as to longitudinal movement and perform the function of holding the trailing end of the leaving rail in a fixed position during the welding procedure. The rear set of grippers, on the other hand, is free to move forward, or toward the stationary grippers, as the pressure and heat bring about the fusing and upsetting of the metal at the rail ends. Pressure is applied through the rear grippers by two hydraulic cylinders, one on each side of the rail.

Design of welding head.

Mounted between the two sets of gripper blocks is the welding head. Essentially the head is comprised of four tip blocks, placed above, below and on each side of the outline of the rail section, each of which contains a series of oxy-acetylene tips. Thus, the abutting rail sections are practically encircled by tips in a plane perpendicular to the longitudinal center lines of the rails. In the tip blocks above and below the rail the arrangement of the tips corresponds in length to the width of the head and base of the rail, respectively, while the face of the block on each side is shaped to correspond roughly to the outline of the side of the rail section and contains tips that are directed toward the side of the head, the web and the upper surface of the base flange.

To permit the heating flames to be oscillated over the desired length of rail, the welding head is suspended from a track-mounted carriage that is operated back and forth longitudinally by means of a shaft from an oil cylinder. Both the length and rate of the oscillating motion are adjustable, and, on the New Haven job, the machine was normally adjusted

Upset metal on the sides of the head and the edges of the base flange at each welded joint was removed by a hand-held vertical wheel grinder.

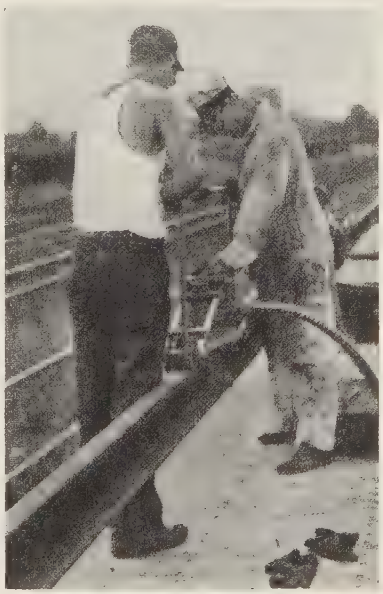
to give a 3-in. movement of the welding head at a rate of 40 cycles per minute.

Control of the flow of oxygen and acetylene is effected by means of separate valves, including a quick-acting shutt-off valve for each tip block, which are mounted on a control panel together with the necessary gages. Auxiliary equipment at the welding machine includes a 5-h.p. 2-cyl. gasoline engine direct-connected to a two-stage vane-type pump which supplies oil to the hydraulic cylinders. This engine also operates a small pump for circulating cooling water through the tip blocks.

Removing upset metal.

When a weld has been completed, the line of rails is pulled forward a rail length by means of a hand winch located near the forward end so that the joints are in a position to permit the newly-made weld to be trimmed by the cutting blowpipe and the next previously-made weld to be normalized simultaneously with the welding of a new joint. In the trimming operation, use is made of a portable cutting machine, specially equipped to adapt it to the requirements of this operation. In brief, the unit consists of a motor-operated carriage on which are mounted two cutting blow-pipes with bevel-cutting attachments.

One of the cutting blowpipes on the carriage is adjusted to a horizontal position and is used to cut off the upset metal on the running surface of the rail in a horizontal plane. The other blowpipe is used to remove the upset metal from the sides of the head and the edges of the base flange in a vertical plane, and from the upper corners of the head on a bevel. The upset metal underneath the



The joints were surface-ground with a roller-carriage mounted cup wheel grinder which was tilted from side to side during the grinding operation.

base of the rail is not removed; when laying the rail provision for accommodating this metal when the joint comes on a tie is made by cutting a hole of the proper size in the tie plate with an oxy-acetylene blowpipe.

Normalizing machine.

In the normalizing unit, which is mounted in a light structural steel frame, the tip blocks, as stated previously, are similar in shape, design and arrangement to those in the welding machine. They are, moreover, suspended from a carriage having a movement parallel to the rail, which may be oscillated in the same manner as the welding head. In the case of the normalizing unit, however, the carriage is moved back and forth by means of a lever in the hands of the operator. A control panel similar to that in the welding unit also forms a part of the normalizing unit.

In the finish grinding of the joints the running surface and the sides of the head, and also the edges of the base, were ground to a smooth even surface. For the surface-grinding work a cup-wheel grinder in a roller-carriage mounting was used, the carriage being tilted from side to side during the operation in order to form the surface to the proper contour. For grinding the sides of the head and the edges of the base flange at each joint, a hand-held vertical-wheel grinder was used. In both cases the grinders were operated by means of flexible shafts from portable power plants of the « utility » type.

For facing the rail ends preliminary to the welding operations, a cup-wheel grinder on a special mounting was used. This device is fastened rigidly to the end of the rail by clamps and embodies a swinging arm that carries the cup wheel at its lower end. This wheel is mounted with the grinding face in a vertical plane at right angles to the rail and is provided with the necessary adjustments to secure a high degree of accuracy in facing the rail ends. The grinding wheel is operated through a flexible shaft from a portable power unit, also of the utility type, and is oscillated back and forth across the face of the rail end manually by the operator. Aside from the facing operation, other preliminary work done on the rail ends included the insertion of metal discs in the end bolt holes to prevent their distortion during the welding process.

As the butt-welding of each of the eight lines of rails progressed in the manner described above, it was moved along on the conveyor line which extended along the center of the string of cars for its entire length. For the storage of the welded rails pending their

One of the station tracks at Hartford after the continuous rails had been laid.

insertion in track, racks were provided on the cars on each side of the conveyor line and, as the welding of each line of rails was completed, it was barred onto one of these racks to make way on the rollers for the next line.

Gang organization.

For conducting all work incidental to the welding operation, an organization comprising 12 men was employed, including 2 grinder operators engaged in facing the rails; 2 operators at the welding machine; 1 man for operating the cutting equipment; 1 normalizer operator; 2 grinder operators engaged in the finish grinding and 4 laborers. With this organization, the average output was about 20 joints per day.

In unloading the rails at the point of insertion, the usual method was employed of anchoring the rail in the desired position longitudinally and pulling the cars out from under it. In laying each line of rails it was first barred back onto the rollers in the conveyor line and one end was fastened to the anchorage, which consisted in this case of several work-train cars with brakes applied. A heavy chain was used to fasten the rail, one end of which was connected to a clevis at the end of the rail while the other was looped around the coupler of the end anchor car. The cars were then pulled slowly out from under the rail and the free end of the latter was allowed to drop directly onto the track. In this manner the rails were unloaded without complications, in spite of the fact that the procedure required the laying of one end of each rail around a curve having a maximum curvature of 6 1/2 deg. The rails can, of course, be pulled off the cars if desired.

The rails were laid on single-shoulder five-hole tie plates and were fastened with compression clips at alternate ties, track spikes being used for lagging the tie plates to the ties. This type of construction was considered by engineers of the New Haven to be sufficient to restrain the rail from movement and for this reason no provision was made for expansion or contraction. For a distance of 100 ft. directly over the passenger subway further provision for reducing noise and vibration was made by placing a rectangular piece of 3/8-in. Fabreeka, a composition material with resilient qualities, under each tie plate to act as a cushion.

Observations made subsequent to the installation indicate that this measure has been successful in accomplishing the desired reduction of noise through the station area.

[621. 135.4]

The motion over curves of multi-wheeled locomotives,

by Chief Engineer AVENMARG, Munich.

(*Glasers Annalen.*)

For many years past designers of locomotives with many pairs of coupled wheels have endeavoured, by using radial wheel sets, to improve their running over curves, with the object of reducing the wear on the head of the rail and the wheel flanges. The most diverse solutions have been tried, the most important and oldest of which were undoubtedly those of Klose, Hagans and Klien-Lindner. Unfortunately they all had the drawback of decreasing the simplicity of steam locomotives, multiplying the number of details used in the construction of these engines, and resulting in increased maintenance work and cost.

Helmholtz and Gölsdorf were the first to retrieve the situation by simply giving the wheels a small side play in the axleboxes and coupling rods, and dispensing with any centering or similar device. The wheels guided themselves by their flanges coming into contact with the heads of the rails. The Class 170 2-8-0 locomotive designed by Gölsdorf 40 years ago, which had an Adams leading pair of wheels, the first pair of coupled wheels rigid, the second with side play, the driving wheels rigid and the fourth pair of coupled wheels also with side play, was a masterpiece from the point of view of running over curves and could not be constructed more rationally to-day. Without having a centering gear, the leading wheels govern the deflection of the locomotive, on entering a curve, by means of the oblique axlebox cheeks, so that the first rigid coupled pair of wheels has only to complete this movement and rotate round the driving axle. As, owing to the side play on the second and fourth coupled pairs of wheels, there is no additional pressure on the flanges, long periods elapse before the tyres are to be returned.

However, the 0-10-0 type locomotive, designed on the same principle and adopted by many railways, soon showed defects. The leading pair of wheels, which was for the first time a coupled pair with side play, guided itself well over the curves, but it left to the second coupled pair of rigid wheels the work of deflecting the whole mass of the locomotive. As this pair of wheels, placed near the centre of gravity, works on a small lever arm and its striking angle with the rail is relatively great, its flanges soon become sharp. This especially showed itself on the G. 10 locomotive of the former Prussian State Railways where unfavourable circumstances were further aggravated by the fact that to avoid long piston rods the centre pair of wheels was chosen as the driving pair. Here again the displacement was carried out by the second rigid coupled pair of wheels, wherely the pressure on the flanges was increased by about 50 %. This arrangement does not appear, however, to have been satisfactory, as this subject was dealt with in the *Mitteilungen* of the Central Office of Railways, Berlin, in 1911. In 1929 it was finally decided to make the fifth pair of coupled wheels rigid and to reduce the thickness of the flanges of the third and fifth pairs of wheels by 10 mm. (3/8 in.). In consequence the first coupled pair of wheels was left with a side play of 25 mm. (1 in.) in both directions, and

the second coupled pair of wheels had to guide the locomotive over the curves as previously. The locomotive works a little more freely over the curves and turnouts because two pairs of wheels have thin flanges; but there is little change as regards flange wear on the second pair of wheels. By making the first pair of wheels rigid and giving twice 25 mm. (1 in.) of play to the second and making the flanges of the third pair of wheels thinner, an improvement could have been anticipated. In this way the rigid wheelbase of 4.500 m. (14 ft. 9 3/16 in.) would be maintained and the prescribed tyre turning intervals would certainly have been increased. This arrangement of the wheels would then have corresponded to that of the Russian 10-coupled locomotive, large numbers of which type have been built by German Locomotive Works.

For tank locomotives, the running qualities of which must be equally good when running forward and in reverse direction, the unsymmetrical arrangement, if one can call it that, of side play of the various pairs of wheels is obviously not suitable. Helmholtz, therefore, logically developed tank locomotives with 4 pairs of coupled wheels, the end pairs of which are mounted rigid in the underframe, while the two central pairs can move transversely (Fig. 1).

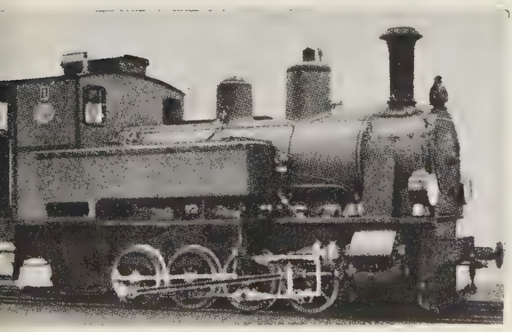


Fig. 1. — 0-8-0 tank locomotive, the second and third pairs of couples wheels of which have side play.

The use of this arrangement, which produces equal wear on the flanges when working in either direction is, however, limited by the length of the connecting rod or, what comes to the same thing, the rigid wheelbase permitted, as in this case the fourth pair of coupled wheels becomes the driving pair.

In order to have also 10-wheeled tank locomotives with acceptable flange wear and as long as possible tyre turning intervals, the *Krauss-Maffei* Locomotive Works fitted a number of locomotives with a guiding arm, principally on locomotives for the mountain lines of Northern Spain. The first German tank locomotive with this arrangement was a 10-coupled engine put in service on the Brohltal line (Fig. 2).

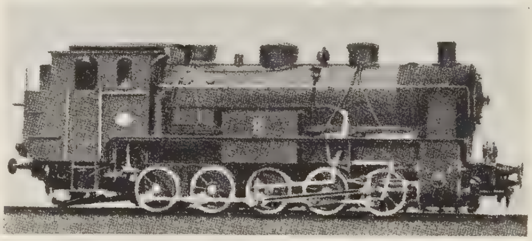


Fig. 2. — 0-10-0 tank locomotive, with guiding arm between the first and second pairs of coupled wheels.

On this line, with 1 in 20 gradients and curves of 50 m. (2 1/2 ch.) radius, the result was most successful. The distance covered by the locomotive between two re-turnings of tyres reached 25 000 km. (15 500 miles) as against 8 000 km. (5 000 miles) on the other locomotives working on the same line. Thereupon 45 0-8-2 tank locomotives of the Bavarian system of the Reichbahn were constructed with this guiding arm between the first and second coupled pairs of wheels (Fig. 3). The fourth coupled pair of wheels forms with the fifth, which is the carrying pair, a Krauss-Helmholtz bogie. The driving

wheels are the only ones mounted rigidly in the underframe. Thus the engine is guided in each running direction by two pairs of wheels and runs over the curves without difficulty.

The last application was to a 10-coupled tank locomotive of the Kassel-Naumburg Railway (Fig. 4). This Railway Company had some locomotives with a first and fifth Gölsdorf pairs of wheels with side play already in service and wished to improve them by reducing the flange wear and make the running steadier at high speeds. The new locomotive was fitted, like that of the Brohltal line, with a guiding arm between the first and second pairs of coupled wheels, the third and fifth pairs mounted rigid in the underframe and a fourth pair with side play. Consequently, in both running directions two pairs of wheels guide themselves whilst the deflection of the locomotive when working forward will be looked after by the pivot of the arm and when in reverse by the fifth pair which is a long way from the centre of gravity of the system. These locomotives fulfil

Fig. 3. — 0-8-2 tank locomotive with guiding arm between the first and second pairs of coupled wheels.

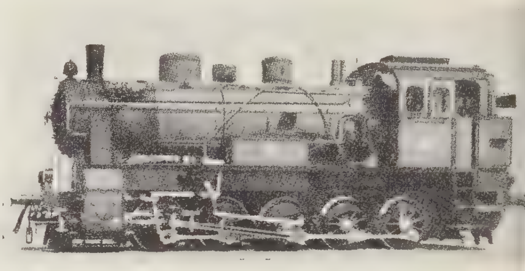


Fig. 4. — 0-10-0 tank locomotive with guiding arm between the first and second pairs of coupled wheels.

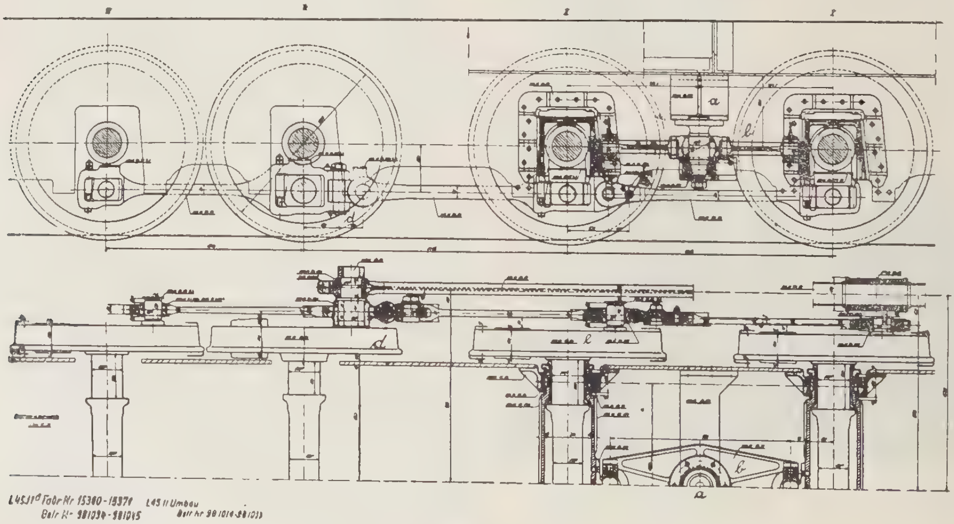


Fig. 5.

the essential condition for steady riding at high speeds, as the rigid wheel base between the third and fifth pairs of wheels is short so that they work over curves without difficulty, and have great guided length from the pivot of the guiding arm to the fifth pair of wheels.

The accuracy of this view was confirmed by the trial runs of this locomotive. It runs over the line with a steadiness greatly superior to that of the old locomotives of the same type fitted with end radial wheel sets, and the tyre returning intervals are longer. Figures 5 and 6 show the arrangement of the guiding arm.

The lever with equal arms *b* between the first and second pairs of coupled wheels, of which each has 2 × 20 mm. (13/16 in.) side play oscillates round a pivot *a* rigidly mounted in the locomotive underframe, and thus carries out the guiding of the locomotive when travelling forward. On a straight track this lever remains in its central position even at the highest speeds, but deflects immediately on entering curves, as has been proved by extensive trials. Centering or check springs are therefore unnecessary. The double lever itself does not need any special care in service, there being only two lubricating caps to feed. When the wheels are taken out, the lever remains on its spring support on the locomotive underframe, and when the wheels are put back again it engages with the driving cams without any detail having to be unfastened or removed. The unsprung weights are not increased by the lever *b*.

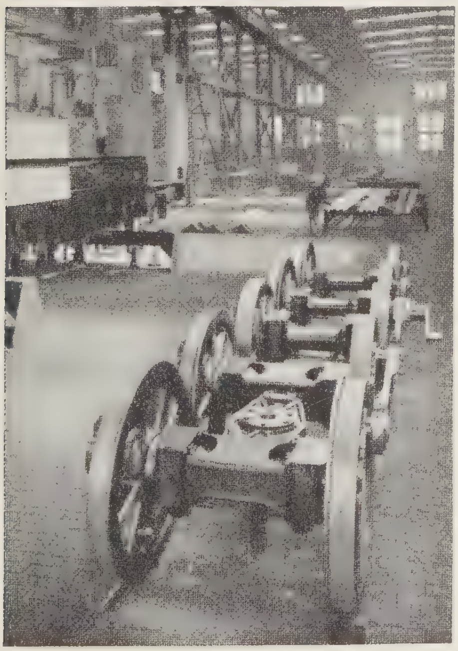


Fig. 6. — Wheel sets of 0-10-0 tank locomotive with guiding arm.

Naturally the coupling rods between the first, second and third pairs of wheels must follow the deflection of the wheels. In order to obtain the necessary mobility, a vertical pin *d* has been provided near the driving crank around which the two front coupling rods can oscillate. The front coupling pin carries with it the rods during the deflection of the wheels whilst the lengthened coupling pin *e* of the second axle is pushed back across the coupling rod bearing.

In order to compensate for the slight obliqueness of the coupling rods in relation to the coupling rods which move parallel (inclination approximately 1 in 150) the rod bearings are fitted with spherical heads, following the method of construction already used for the standard German State Railways locomotives, classes 43 and 44. The large coupling pin has to take up the slight lateral force which is produced and therefore receives a suitable shape.

The guiding arm preserves the flanges and, consequently, also the track; owing to the simplicity of its construction, it is a remarkable advance in the general arrangement of locomotives having many pairs of coupled wheels, intended for running easily over curves in both directions.

[656. 231 (.89)]

A simplified rate classification in Uruguay.

A new scheme which provides an automatic goods classification designed to place rail and road transport on a equality.

(*The Railway Gazette.*)

Owing to the serious encroachment of road competition and consequent loss of traffic, the Central Uruguay Railway decided, in July, 1936, to take drastic measures by introducing an entirely new system of classifying and rating merchandise, and there follows hereunder a description of the main aspects of this revolutionary scheme.

Outline of scheme.

In general terms, the scheme was designed to put the railway on an equal footing with lorries as regards rate charged and unification of load. The old system of several classifications based largely on the intrinsic value of commodities, each with a minimum charge (and the application of the highest rate where a mixed classification was concerned) left the railway at a grave disadvantage *vis-à-vis* the road haulier, to whom a ton is a ton, be it of silk stockings or fencing wire. Moreover, the system of ordinary goods tariffs designed on the usual tapering curves (in force prior to July, 1936) was fundamentally obsolete, as it pre-supposed monopoly of transport by a wide differentiation between « high » and « low » grade goods, and charges proportionally higher for short than for long haul. Added to this was the fact that, up to the time it was decided to make a change, the bulk of the railway's traffic was handled at special tariffs, of which no fewer than 8 000 were in existence, and this unfortunate necessity introduced anomalies inimical to traffic development. The new scheme also contemplates, as a primary factor, the value of services rendered, i.e., the actual cost of transport, not merely the value of the article transported.

First and foremost, therefore, the classification of commodities in various categories was entirely suppressed, and merchandise divided into two main classes consisting of : (*a*) wool, hides, and skins, and (*b*) all other articles; the separation from the remainder of the three traffics specified in (*a*) was based on their volume or weight ratio, justifying the application of slightly higher rates.

Very low rates were entirely eliminated, with the result that broken stone is now rated basically on an equality with general merchandise. To adjust theory, however, to practical fact, a sliding scale of charges was established varying in inverse ratio to the volume of the consignment, so that, with broken stone moving normally in consignments of 50 tons and above and grocery in consignments of from 1 to 10 tons, each automatically fell into its propre place in relation to the other, while the basic cost factor was retained in each case. This method is superior to that in which rebated rates were conceded in return for a tonnage contract, in that it contemplates the actual fundamental economics of railway operation — in other words, full wagon loads, full engine loads, and the reduction at terminal and intermediate stations of the handling of isolated wagons.

As a complementary measure new formulæ for rating were evolved from a

study of traffic density (ton-kilometres) and the characteristics of lorry competition in the various zones served by the railway. The practical result of this was to make the rate per ton-kilometre higher as the distance from the capital increases — *i.e.*, in the zones more remote from competition; to cite an example, a ton of traffic carried 25 km. in a zone near the capital now pays a considerable cheaper rate than it would for the same distance 300 km. further away, and the rates have been scaled in such a way that the sum of those corresponding to a number of stages is equal to that applying to the throughout distance.

Evolution of rating formulæ.

1. *Zone Factor « Z ».* — The construction of excellent roads parallel to the railway and the exploitation of water routes resulted in endowing large areas of the country with new « geographical privileges » in relation to other zones, and the rating system adopted had to be flexible enough to take these privileges into account, for a railway cannot apply high tariffs, however justifiable they may be economically, if a cheaper form of transport or a more direct route be available to traders. Therefore the zone conditions were assessed and expressed in terms of ratio, determined by the nature and routing of roads, prevalent gradients, etc., and relative level of lorry (or water) transport costs; by keeping to ratios, the figures could be made to hold good for large or small vehicles, owner-driven or company-operated, economically worked or extravagantly handled; the only premise is that, if in a given zone a lorry can operate at « X » cost, then its costs will be in the order of 20 per cent higher in a zone which bears to the former a ratio of 1.2 to 1. Road traction ratios were determined by an exhaustive series of surveys; these were plotted as curves, and by the incorporation of such considerations as arose from the relative distances by road and rail, and from any water route virtually short-circuiting the railway, were classified as « Goods tariff zone ratios ».

As a corollary of the foregoing, the zone dsitance factor formed of zone-factor « Z » multiplied by distance in kilometres « D » becomes, in effect, a compensated kilometrage-table, applicable strictly geographically, and possessing superiority over the old kilometric scale, which pre-supposed equality of zone conditions throughout the line.

2. *Commodity Index « I ».* — Reference has already been made to the abandonment of the old and complex goods classification and the concentration of merchandise in two broad categories : (*a*) wool, hides, skins, etc., and (*b*) all other goods. It should now be mentioned that (*b*) is subdivided, by admitting a lower zone distance factor for wheat, maize, rice, etc., which, because of their bulk movement and special economic characteristics, it is necessary to consider as a class apart. Reference has also been made to the sliding scale of charges varying in inverse ratio to the volume of the consignment. In effect, this means that the first ton has a higher rate than each ton of the subsequent five (or ten), which in turn is higher than each ton of the subsequent fifty, and involves a variation of the commodity index « I », covering a range from 3.1 to 1.9. The level of these indices has been determined by equating a known traffic (that of the previous year) in zone-ton-kilometres, so as to yield a given total revenue, and the relation of the indices one to another has been settled by the consideration of lorry practice. In short, the whole thing is the result of trial calculations, with a view to evolving a compromise between high figures (advantageous to competitors) and low figures (sacrificial of potential revenue).

3. *Terminal Factor « T ».* — All handling and terminal costs are regarded as constants, and added to freight calculated by formula. In order to give it flexibility, this factor has been designated as a constant per consignment, plus a constant per 100 kgr.; *e.g.*, the rate for a large consignment of fencing wire would bear a given relation to the cost of alternative transport, yet a consignment of 100 kgr. would pay more per ton, not only because of the sliding scale of indices, but also by the incidence of full per consignment terminal.

Map of Central Uruguay Railway showing zoning.

The following is a working expression of the basic formula of the new tariffs, without taking into consideration the effect of the variables : $I \times ZD + T$ = tariff per ton in local currency. Fully expressed — *i.e.*, taking the variables into account — the formula in its complete form would be :

For consignments not exceeding 1 000 kgr. :

$$K + WI\ (ZD) + nk = Tf.$$

For consignments exceeding 1 000 kgr. but not greater than 5 000 kgr. :

$$K + WI\ (ZD) + nk + W_1\ I_1\ (ZD) + n_1k = Tf.$$

For consignments of over 5 000 kgr. but not exceeding 50 000 kgr. :

$$K + WI\ (ZD) + nk + W_1I_1\ (ZD) + n_1k + W_2I_2\ (ZD) + n_2k = Tf.$$

where K is the fixed charge per consignment; k the terminal per unit of 100 kgr.; ZD the zone-distance ratio; W, W_1, W_2 the weight in kgr. respectively, between 1—1 000 kgr., 1 001—5 000 kgr., and 5 001—50 000 kgr.; I, I_1, I_2 the commodity indices, for the same range; n, n_1, n_2 the number of units of 100 kgr.; and finally Tf the total charge in pesos.

Values assigned to factors.

As a result of the zone surveys, the following zone factors (ZD) were adopted :

Z = 1	Central—25 de Agosto 25 de Agosto—San José Mal Abrigo—Colonia Rosario—Puerto Sauce Cardona—Mercedes Sayago—Pando	
Z = 0.8	Pando—Minas	A highly competitive zone served by a first class macadamised road, which also drains an extensive area beyond Minas.
Z = 1.05	San José—Mal Abrigo 25 de Agosto—Florida Toledo—Fray Marcos Retamosa—Treinta Tres	These are zones in which railway operating costs progressively increase due to diminishing density of traffic, and in which road competition is progressively less intense.
Z = 1.1	Florida—Durazno Mal Abrigo—Cardona	
Z = 1.15	Nico Perez—Retamosa	
Z = 1.25	Fray Marcos—Nico Perez	
Z = 1.3	Durazno—Paso de Los Toros	
Z = 1.5	Paso de los T.—Tacuarembó Nico Perez—Melo	In these zones proportionally higher rates can be applied to raise the general level of the average.
Z = 1.75	Tacuarembó—Rivera	

It should be noted that for wheat, maize, rice, etc., a separate series of ZD coefficients is applied, using unity as the zone factor, wherever the normal scale shows a higher reading. In order to comprehend more fully the system of zone assessment and rating, reference should be made to the map of the Central Uruguay Railway.

With regard to the goods indices (I), the following are the values assigned :

Wool, hides, skins, etc.

Each ton up to 10 tons	In same consignment	2.9
Each ton above 10 tons		2.7

Other goods.

First ton	In same consignment	2.6
Each ton of subsequent 4 tons .		2.3
Each ton of subsequent 45 tons .		2.1
Each ton of above 45 tons . .		1.9

Terminal factors (T) have been fixed at :

Per consignment	\$0.25
Per 100 kg. or fraction . . .	\$0.05

For publicity among clients of the railway and for employees' use a table was prepared for each station, embodying the ZD factors applicable between that station and all others on the system. Hence no calculation of any kind is necessary to obtain a coefficient from

which, by reference to a ready reckoner, the actual freights in currency are extended in the appropriate column corresponding to the respective item of the goods indices, leaving only to be added the terminals, which obviously cannot be reduced to a per ton basis.

In summarised form, the new scheme provides an automatic goods classification, spacing out, relatively widely, goods habitually handled in wagon or train loads from those normally moving in small lots.

The new rates do not apply to interchange traffics with Brazil, the Midland Railway group or the State Railways Eastern Line; but, with the elimination of these, figures illustrative of the success of the scheme show that, notwithstanding a heavy decrease in wheat tonnage, the traffics to which the new rates apply have so far given satisfactory increases, principally from previously low-rated commodities such as stone, and despite the considerable decrease in revenue due to lower rates from what was previously the highest rated traffics.

[625. 232 (.42)]

New buffet-restaurant car for York-Swindon service.

An important service operated by the London & North Eastern Railway Company is that which conveys through carriages from Aberdeen to Penzance and the South of England. The train leaves Aberdeen at 10.20 a. m. each week day, and by way of Edinburgh, York, Sheffield and Swindon, passes to the Great Western line.

The restaurant-car service is provided by the L. N. E. Company, and in order that facilities may be available for the provision of substantial meals or light refreshments, two new vehicles known as Buffet-Restaurant Cars have been specially built for this service.

The cars were constructed at the Doncaster and Dukinfield Works of the L. N. E. Company, to the designs of Sir Nigel Gresley, Chief Mechanical Engineer, to whom we are indebted for this information, and combine the facilities of a restaurant-car with those of a buffet car. There are two saloons in each vehicle, one being arranged for dining purposes and having accommodation for 12 passengers, the seats and tables being of the usual restaurant-car type, whilst the other portion of the car is arranged on similar lines to a buffet car and is fitted with fixed seats of a special design. These seats are upholstered in green leather and the seat adjacent to the gangway is hinged to facilitate access to the tables. There is accommodation for 18 seated passengers, whilst further standing room is available at a small bar.

The floor of the buffet portion is

Inside the restaurant section of the car.

Buffet compartment with bar in background.

covered with « Gesco » cork tiles and the screen separating the buffet portion from the dining saloon is provided with « Perspex » panels so that the staff may have a clear view the full length of the car.

The walls of the saloons are finished in coloured Rexine relieved by bands of anodised aluminium.

A large combined kitchen and pantry is provided for service to both saloons, the cooking being carried out entirely by electricity. The Stone-Wilson cooking stove provided in the kitchen comprises a roasting oven, three boiling plates and two grills. A separate fish fryer is provided, together with a Still's automatic boiler for the provision of tea and coffee, and a large electric refrigerator.

The power is derived from two 10-kilowatt axle-driven generators suspended beneath the vehicle, and an Exide-Ironclad battery of 210 ampere-hours capacity provides current whilst the train is standing at stations.

The vehicles are of the L. N. E. standard teak construction and are fitted with buckeye couplers, Pullman vestibules, and are mounted on L. N. E. standard compound bolster bogies. The weight of the vehicles is 41 tons 11 cwts 3 qrs.

MISCELLANEOUS INFORMATION.

[625. 154 (.44)]

1. — Turntable extension carrier to accommodate long-wheelbase wagons,

by Mr. MARJOLLET,

Ingénieur principal adjoint à la Division du Mouvement, French National Railways Company, Eastern Area

(Revue Générale des Chemins de fer.)

Traffic demands and the necessity for improving equipment by increasing the useful load of wagons in comparison with their tare have caused railway companies to increase the size of their wagon stock. In the same way the number and capacity of privately-owned wagons have been constantly increased on account of the more advantageous rates applied to them.

The use of these wagons could not, however, be extended to the whole of the existing plant, since the increase in wagon capacity necessitated increasing the wheelbase of the wagons to such a degree that they became too long to use the existing turntables. There are at present in service four-wheeled wagons with a wheelbase of 5 to 6 m. (16' 5" to 19' 8") and sometimes more, whilst most of the turntables have a diameter not exceeding 4.50 m. (14' 9") and can thus only accommodate wagons with a wheelbase of less than 4 m. (13' 1 1/2").

To obviate these difficulties, some turntables have been replaced by larger circular turntables, or by bridge turntables, at a high cost, but in most cases the available space or neighbouring obstacles have not allowed the installation of a cumbrous plant of this nature.

The device described below, whilst having a lower installation cost than that of a new circular or bridge turntable — in some cases as much as 50 % less — provided a simple solution of the problem of turning long-wheelbase wagons on the existing tables.

Figure 1 shews the device as it was applied for the first time to a turntable at Paris-La Villette.

A samll auxiliary carrier or truck, called « Chariot-satellite » and constructed after the fashion of a traverser, with articulated runners and carrying rails, can, with one pair of wagon wheels resting on it, run on a path concentric with the turntable, whilst the other pair of wheels rests at any point on the table according to the wagon wheelbase. Synchronous rotation of the turntable and of the extension truck is ensured solely by the adhesion of the wagon placed astride on the two devices.

As the extension carrier is required to work on a curve of very short radius (approx. 5 m.

Fig. 1.

16' 5") whilst supporting a load of 15 to 20 tons, i. e. about half the weight of a loaded wagon, the running and guiding parts have had to be designed to reduce friction to a minimum and to facilitate movement as much as possible.

The extension carrier is carried on only four wide round-rimmed rollers without tyres or flanges, mounted on roller bearings and set at an angle to work over the specified are of a circle on the flat iron runways concentric with the turntable.

These runways, which are set on a concrete base, are situated at the same level as the track rails so that the four rollers, by reason of their design and arrangement, can negotiate without mishap the gaps between the rail and the stock rail at the crossings.

The carrier is guided by an arrangement which constitutes one of the novelties of the system, i. e. is provided by two round steel rods which project vertically from the floor of the extension carrier on its centre line, and can rotate in the manner of a journal end in ball bearings fixed in the carrier frame (fig. 2).

These rods slide in a channel or guideway and have slight play. The guideway is concentric with the turntable and made up of two U irons, curved and stayed, and fixed in concrete, equidistant between the two runways; this channel is deep enough to remain effective when the carrier passes over the gap between rail and stock rail, and the guide rods are sufficiently long to remain constantly engaged and so exclude the possibility of a derailment.

The top of the guide channel is flush with the rail top, and the rails are slotted in one place only to allow the guide rods to pass.

In the case of a quarter-circle arrangement, that is to say for the accommodation of wagons on two roads at right-angles, which is usually limited by the exterior rails of the two roads served by the extension carrier, there are normally only two rails slotted, and at only one place. If it is desired to turn wagons right about, a semi-circular runway only need be provided.

In view of the fact that the carrier is not in any way an integral part of the turntable, it can be removed at will : thus there remains no obstacle on the line when the carrier is not in use, and the turntable may be used in the normal way for wagons of small wheelbase.

When not in use the carrier is generally left on the runway between the angle of the two roads if the location allows this to be done (fig. 1).

When the carrier can not be left here, however (for example, in the presence of other roads as shewn in the foreground in figure 3) the carrier can be stationed at any convenient point by running it on four slightly superelevated auxiliary rollers on two supplementary runways, also superelevated, which may, as in the case shown in figure 3, describe a curve in the opposite direction of that of the normal runway. This curve is provided by the channel guideway, which may be bent if required (see fig. 4), and the carrier remains guided over its whole course by the two guide rods.

The length of the carrier and the radii of its runways depend on the wheel-bases of the wagons to be turned. The installation at Paris-La Villette includes a carrier of 1 m. (3' 3 3/8") span, and the guideway is set at 5.25 m. (17' 2") from the pivot of the turn-

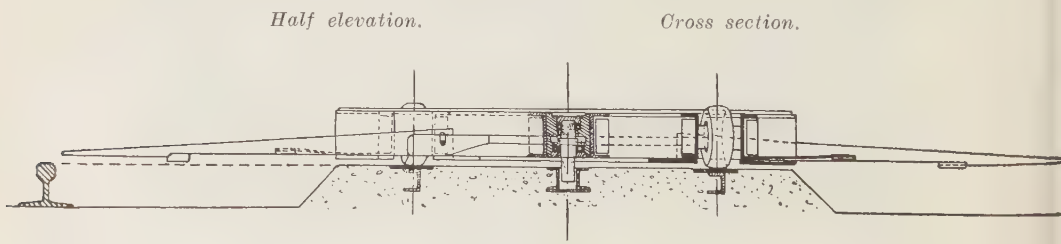


Fig. 2.

Fig. 3.

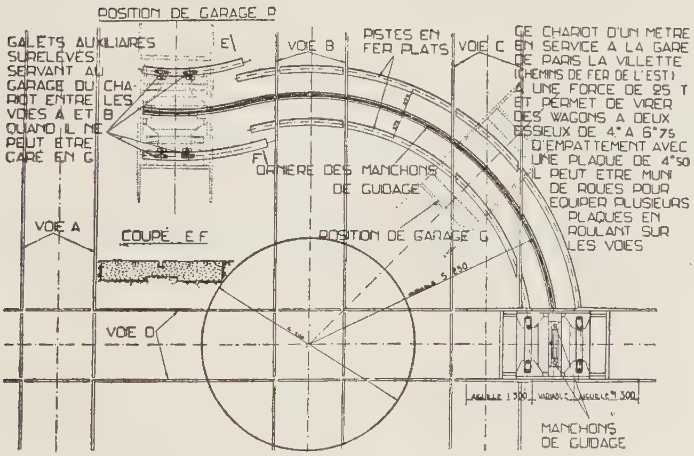


Fig. 4. — Extension carrier for turntable.

Explanation of French terms :

Position de garage = parking position. — Voie = track. — Pistes en fers plats = runway made of iron flats. — Ornière des manchons = channel for guiding rollers. — Galets auxiliaires... = auxiliary super-elevated rollers for parking the carrier between roads A and B, when it cannot be left at G. — Ce chariot d'un mètre... = this 1-m. (3' 3 3/8") carrier in use at Paris-La Villette station carries a load of 25 tons and allows the turning of 4-wheeled wagons of 4 to 6.75 m. (22' 3") wheelbase on a table of 4.5 m. (14' 9") diameter. It may be provided with wheels to run on rails, and so be available for several tables.

table, which is of 4.50 m. (14' 9") diameter. The table can only turn wagons of 3.90 m. (12' 9 1/2") wheelbase or less, whilst the

Fig. 5.

combination of turntable and carrier will accommodate four-wheeled wagons of 3.90 m. to 6.75 m. (22' 3") inclusive.

The turning operation, using the carrier, does not involve the use of any more time or labour than with the table alone. The operation may be done manually by pushing the carrier end of the wagon and this is sufficient to assure the synchronous turning of the table and carrier (fig. 5).

Bogie wagons may also be turned with the same device. By means of a carrier of 3.50 m. (11' 6") span, with the guideway situated at 6.65 m. (21' 10") from the pivot of a 4.50 m. (14' 9") diameter table, all wagons, four or eight-wheeled, of up to 9.80 m. (32' 2") wheelbase could be turned. At the same time, to complete the arrangement for turning bogie wagons, it is necessary to provide a very simple device for rendering the wagon body rigid with the turntable, to prevent the body displacing itself obliquely in relation to the bogie which is resting on the table.

There are at present five extension carriers in service, two of which have been in use for three years at Paris-La Villette, where they are in daily use for turning many wagons. Their maintenance is cheap and simple, and their working has always given satisfaction.

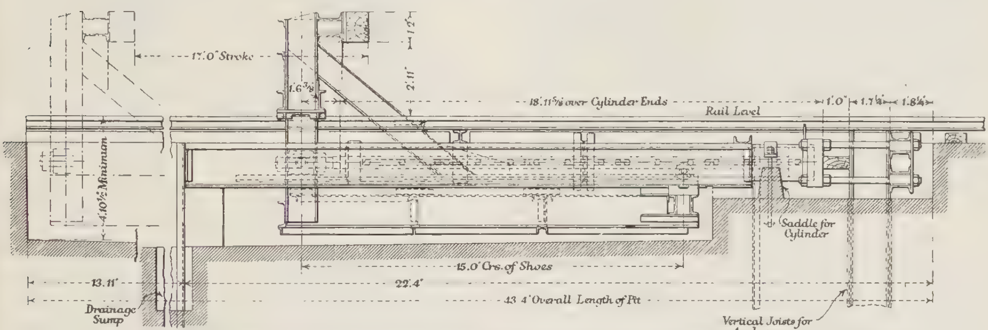
[625. 156 (.42)]

2. — Hydraulic buffer stop at Aldgate East Station.

(*Engineering.*)

In the issue of November 4, 1938, page 531, of *Engineering* a description was given of the reconstruction of the Aldgate East station of the London Passenger Transport Board. In connection with this work a new buffer stop, the first of a new type, is in course of manufacture at the works of Messrs. Ransomes and Rapier, Limited, Waterside Ironworks, Ipswich. The new buffer stop, which is illustrated in figs. 1 to 4, works on the well-established hydraulic principle in which the resistance is obtained by the movement of a piston in a cylinder containing fluid, oil being used in the present instance. The outstanding feature of the new stop is that an unusually long stroke is obtained. With the ordinary type of buffer stop, in which the piston rod is in compression during the retardation of the train, the stroke is limited to a maximum length of about 11 ft., and as a stroke of 17 ft. was required in the present instance, the installation was designed with the piston rod in tension. The buffers have a maximum duty of stopping a train weighing 300 tons and moving at 13 m.p.h. The resistance, which is practically constant throughout the stroke, is 106 tons. The arrangement of the installation is shown in figs. 1 to 3. It will be seen that the buffer stop is built into a pit 4 ft. 10 1/2 in. deep, and that it consists of a braced buffer structure, provided at one end with shoes which slide along the track rails, the vertical reaction being taken by a slipper on the underside of the pitside girders. These girders are 22 ft. 4 in. long, and they carry the track rails over the span of the open pit on their upper side. As shown in figs. 1 and 2, the buffer structure is con-

Fig. 1.



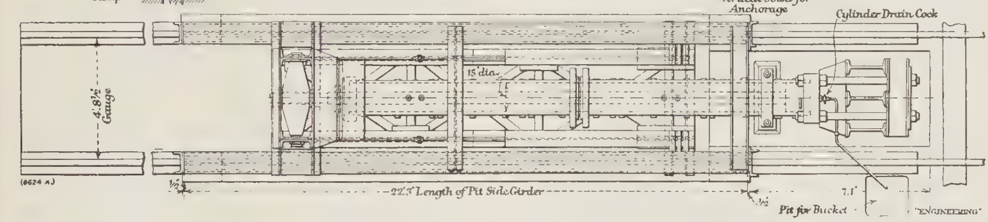


Fig. 2.

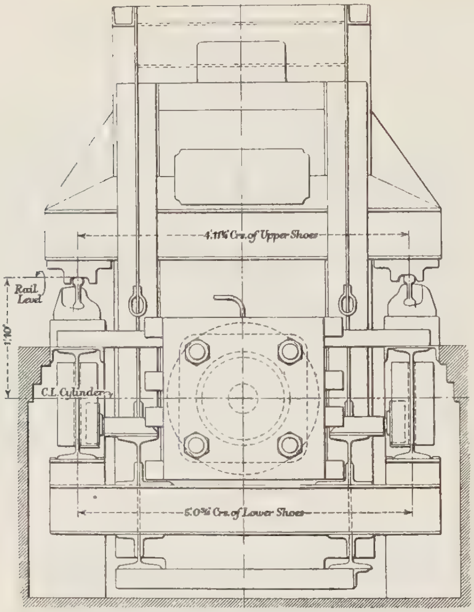


Fig. 3.

nected to a piston rod with the piston working in a hydraulic cylinder of sufficient length to accommodate the full stroke of 17 ft. The cylinder is securely anchored, as it has to resist the full retardation force of the buffer. The anchorage, shown in figs. 1 to 3, consists of four 3-in. diameter bolts with suitable cross girders connected to three vertical joists built into the foundation. Reinforcement below the pit level is provided for securing these girders. The cylinder is also supported by a saddle and strap shown in fig. 1, and by a cross girder between the two pitside girders towards the front end.

The cylinder is 15 in. in internal diameter, and consists of two lengths of solid drawn steel tube joined at the centre by means of flanges screwed on and bolted together. The cylinder tubes are also screwed at the rear end to receive the anchorage, and at the front end to receive a gland, fitted with a U-shaped leather, as shown in fig. 4, which prevents leakage along the piston rod. The rod itself is connected to the buffer structure by a swivel joint, shown in figs. 1 and 2, to relieve it of all bending stresses. The piston is provided with two longitudinal rectangular slots, which work over two tapered strips fixed inside the cylinder. Due to the taper of the strips, a diminishing area for the passage of the oil from the front to the back of the piston is provided throughout the stroke. The area of

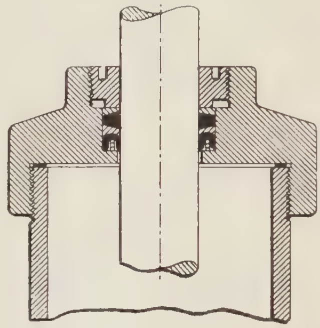


Fig. 4.
Section through cylinder end cover.

the orifices is so designed that the retardation force is constant. The cylinder is provided with a plug, and with air-release cocks, for use when filling or replenishing the light oil used. The centre line of the cylinder is 1 ft. 10 in. below rail level, and approximately 5 ft. 4 in. below the buffer level, so that considerable overturning effect will occur on impact by the train. For this reason, the buffer structure has a length of 15 ft. between the centre of the upper shoe, running on the track rail, and the centre of the lower shoe, running on the underside of the pitside girders. As shown in the figures, the structure is well braced and gusseted to resist distortion on impact, and a timber buffer is fitted on the cross girder. Automatic resetting of the stop was not required on this installation, and shackles are therefore fitted to the diagonal supports, at the rail level, as shown in figs. 1 and 2, for the attachment of rope tackle. The overall length of the pit for the installation is 43 ft. 4 in.

[385. (06 111]

OFFICIAL INFORMATION.

List of Members of the Permanent Commission

OF THE

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R. **Le Besnerais** (³), directeur général de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IXe).

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Sir H. Nigel **Gresley** (¹), C. B. E., D. Sc., chief mechanical engineer, London & North Eastern Railway; King's Cross Station, London, N. 1;

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(²) Retires at the 15th session.
(³) Retires at the 16th session.

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(1) Retires at the 14th session.
(2) Retires at the 15th session.
(3) Retires at the 16th session.
(*) Situation at the 11th July, 1936.

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E. **Minsart,** ingénieur principal au Service du Matériel de la Société Nationale des Chemins de fer belges.

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